

Building What?

The Challenge of Introducing Alternative Building Practices into the
Aqaba Built Environment

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Abstract

For cities growing in conditions of extreme heat and aridity, adapting their building stock to reflect these environmental challenges demands a social as well as technical shift. Aqaba in southern Jordan is embarking on this process. Extremely poor building thermal performance coupled with a lack of public understanding of basic energy principles is contributing to social and economic stress in Aqaba. People are spending a large proportion of their income on air conditioning alone; up to 30%. Tests show that a slightly more expensive building than standard, comprised of alternative building materials and altered orientation can have a dramatic impact on cooling costs. In this case a 9% first-cost premium is returned in cooling cost savings in less than 2 years. Despite the promise of alternative building options, adoption of alternative building practices with improved social, economic and environmental performance; coined 'Beige' building in this context, will be highly unlikely without coordinated pressure. A combination of entrenched institutional behaviours, no regulatory forces, low levels of technical awareness and capacity, combined with public values incongruent with the concept of Beige-building means systemic change is needed to improve the Aqaba building stock. Assessing barriers through the lens of diffusion of innovation theory, ground-up, educational, regulatory and capacity raising mechanisms are suggested as key to promoting Beige building in Aqaba.

Executive Summary

The City of Aqaba lies within the Aqaba Special Economic Zone (ASEZ) at the southern apex of Jordan. It plays host to a rapidly growing population of 104 000 (set to double) and seeks equally rapid business investment in what is hoped will be “an engine of growth for Jordan”. The ASEZ government authority (ASEZA) is aware the built environment of Aqaba is not ideal and wishes to see an improvement in the local building stock.

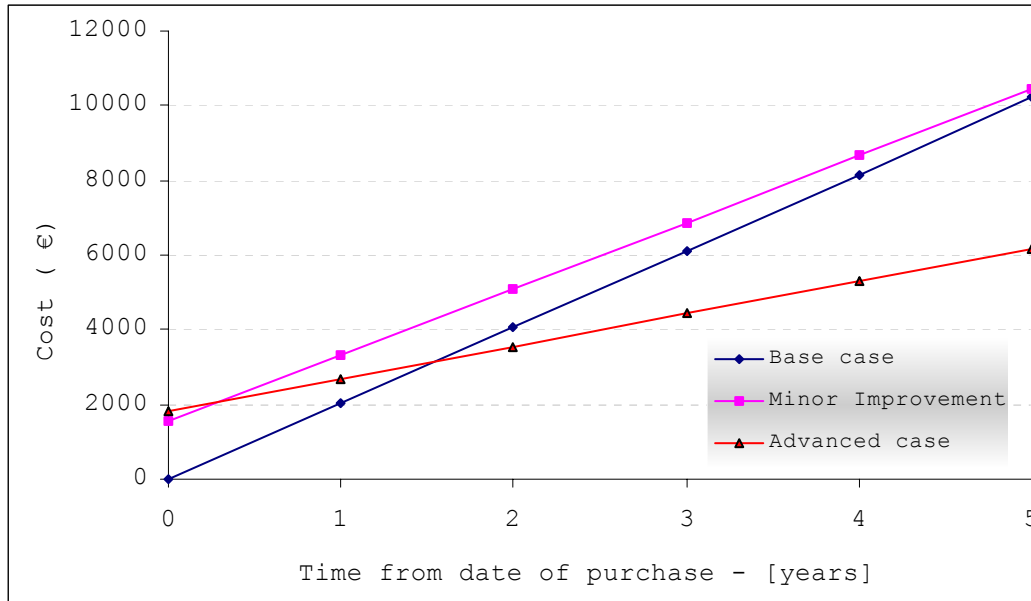
Focusing on the residential building stock, the normative stance is taken that aiming for social, economic and environmental sustainability should be the ideal in any built environment. In the context of Aqaba, where attaining sustainability and ‘Green building’ environmental excellence is not a reality at this stage, the term ‘Beige building’ is coined to describe building with improved social, economic and environmental performance. This study answers three problem issues: *where and how do alternative building options out-perform the conventional? What forces influence persistence of the conventional? And: What can be done to promote adoption of ‘Beige’ Building?*

Alternatives Outperform the Status Quo

Results showed that alternative forms of buildings, termed ‘Beige’ building in this context, outperform the status quo on a number of technical fronts. The built environment in its current form is directly contributing to social, economic and potentially environmental stress in the ASEZ. Its design, material composition and spatial layout does not reflect the environmental conditions of the region and locks-in a costly and resource intensive occupancy lifestyle that is ill-suited to both the regions’ scarcity of resources and its low income majority. Typical construction styles have poor insulating qualities and fall above the national code requirements for maximum U-values set for whole walls [$1.8 \text{ W}/(\text{m}^2.\text{K})$] and roofs [$1.0 \text{ W}/(\text{m}^2.\text{K})$]. Only anecdotal evidence suggested that mildly insulated buildings exist.

Assessment of relevant literature and local environmental conditions revealed that Aqaba has an untapped opportunity in correcting building orientation to align north-south giving free improvement in heat rejection and ventilated cooling and for reducing thermal gain. Water use can be improved through re-use of grey-water for toilets, providing aesthetic improvements through plant irrigation and subsequent reductions in heat gain due to shading. Alternative cooling options such as geothermal cooling and solar dehumidification are also likely to prove advantageous for large structures but not cost effective for widespread residential adoption at this stage.

Simple calculations were made of three building styles to assess the impact of material and orientation changes on building skeleton cost and cooling requirements. The control (‘Base’) case copied conventional Aqabian materials, a second (‘Minor-improvement’) case incorporated a small amount of polystyrene insulation in the walls and the third (‘Advanced case’) was a strawbale and concrete construction with polystyrene used in the roof. Key results showed the ‘Advanced-case’ would require a 9% first-cost premium compared to the ‘Conventional-case’ but that lower cooling requirements in the advanced building enabled savings greater than the first-cost premium in around 1.5 years. Payback periods are shown in the following figure.



Cost impact (including air-conditioning) of additional investment in improved housing design

Despite the opportunities, the building market in Aqaba is strongly influenced by forces supporting the endurance of the status quo. Beige building represents an innovation in both production technique and product service but it suffers from chronic diffusion problems. Forces retarding diffusion are complementary and pervasive, emerging in regulatory, institutional, commercial and social decision-making. Despite people being concerned about the costs of the built environment, they look up to some of the most resource intensive styles and do not see the need for change. Furthermore, many people are not making the link between building design and its influence on thermal comfort and cooling cost. For many Aqabians, a low general understanding of what alternative building options exist and what these could mean for them and the ASEZ severely limits their perceptions of how any benefits can be gained from adopting improved building techniques. While individuals in the local building industry are interested in trying new ideas they have little awareness or capacity to provide any demand market with successful 'Beige' buildings. As a whole the industry is suffering from inertia, it is also fragmented and lacking in any local leadership. It is deeply driven by cost cutting forces and ridden with a culture of code abuse, while also content with the high prices that the booming market currently provides. The residential housing supply market is also occupied by many 'opportunist' contractors having little professional training.

Furthermore, antagonistic, distrustful and uncooperative relationships between small scale building firms, the local population and the local authority are strongly evident. They are undermining current ASEZA efforts to enforce its few building codes and will completely undermine any efforts to tighten regulation or promote 'Beige' buildings in Aqaba if nothing is done to change this. The relationship between ASEZA and the local community is in a critical state with ASEZA having a serious public credibility problem. This has implications for what steps can be taken to promote beige buildings and who needs to be involved.

A Step Forward

The introduction of Beige buildings into the mainstream requires a combination of mechanisms working in a coordinated fashion. These must be educational, capacity raising and regulatory.

Education is the most important mechanism needed but also least likely to create change on its own. Education mechanisms need to subtly address the positive perceptions of the status quo and raise awareness of the benefits gained from alternatives. Benefits need to be clearly presented to the community as well as the local professional associations and trained industry stakeholders who all have much to gain from a shift to Beige-building. A thoroughly ground-up approach to education and awareness-raising is critical to prevent messages coming from ASEZA being viewed through the current lens of distrust and antagonism. The engagement of a vibrant, and united community would be ideal in this process but there is no evidence of this kind of community culture existing and no efforts on ASEZA's part to promote it. External help may be needed to begin a process of community empowerment.

Additional key mechanisms needed are:

- A set of attainable minimum industry standards for benchmarking performance and additional standards for medium and advanced levels of building performance.
- Demonstration buildings involving on-site training, public access and a point of access for educational materials.
- Industry workshops and possibly an industry information exchange centre
- Re-formation of existing regulations and codes to better direct professionals toward higher performance and removal of regulatory loop-holes
- Increased regulatory compliance checking and enforcement- through enhancement of existing mechanisms

Without dramatic change in the building stock, the ASEZ will lose credibility as a unique investment opportunity and city, bringing growth through sustainable development. Its' majority population with low income levels will be forced to either migrate or suffer ingrained poverty from dramatically rising resource prices; this has the potential to deeply undermine community stability. The challenge of mainstreaming Beige buildings represents an important first step of change and a social, economic and environmental necessity for Jordan's burgeoning 'engine for growth'.

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1 Introduction

Few cities have taken up the challenge of developing or adapting their built environments to reflect the social and environmental context in which they exist. Aqaba is one urban centre with unique possibilities to shift its built environment away from the high energy, high resource consuming urban homogeneity that characterises its status quo. Aqaba also represents a type of city which is typical throughout hot, arid regions of the world; limited by resources, home to a rapidly growing population and in search of a unique identity. Its decision makers are keenly aware that improvements to the city's stock of buildings can be made and they desire to see a change for the better occur. This research shows that it is both a possible task and a challenging one; faced with barriers that are primarily social rather than technical in origin.

But what does a change-for-the-better mean?

In this thesis the belief is taken that the built environment is not merely an end product. Rather, it should be seen in the context of its requirements for space, energy, material and personal resources (including time) that are synonymous with physical, spiritual and economic impacts on the human and natural world. A sustainable built environment: one that meets the needs of its current users while not compromising the future needs of generations or natural ecosystems is seen as an admirable ideal that should be strived for. This value judgement extends to the attitude that the 'failures' of the built environment (examples where its impacts compromise human and ecological needs) should be reduced and eliminated. However, in making this thesis, it is recognised that a sustainable built environment and sustainable building lies the proverbial 'light years' away for Aqaba. This thesis therefore makes no pretentious gestures at sustainable development but presents an assessment of environmental, social and economic problem issues in Aqaba's building stock and presents feasible options for reducing its high impact and overcoming barriers to this positive change.

In the creation of a single building, environmental impacts can be measured in the construction, rebuilding, expansion, use, upgrading and demolition phases of its life (Erlandsson & Levin, 2004). These impacts include over-use of natural resources such as groundwater, destruction and degradation of habitat, associated species loss and pollution of the land, air and sea (Blair et al., 2003). Despite systematic efforts to deliberately reduce resource use of buildings (primarily energy) in industrial societies as early as the later 19th Century, according to Building Design & Construction (2003), the 1973 oil crisis triggered a wider societal re-think of resource use in building that was hitherto restricted to alternative sub-cultures in Western societies. Deliberate and successive adaptations to the status quo in buildings have evolved. Alternative building examples show that many costs and environmental impacts associated with conventional construction practices are unnecessary and can be reduced if buildings are designed and constructed with a conscious understanding of the environment in which they are placed.

1.1 A Problem of Definition

A rash of loosely defined terms exist for the variety of building techniques that represent social, environmental and economic improvements on the status quo of building (Blair et al., 2003). In the context of this thesis I have tried to stick to a few terms to describe different building approaches without causing confusion:

- The terms *status quo* and *conventional building* are used to highlight styles and processes which characterise existing buildings and current building trends in Aqaba.

- **Alternative building** is generically used to describe any style of building that outperforms the status quo in terms of improving its social, economic or environmental impact.
- **Green Building** as either a noun or verb both the end product and process by which buildings aim “*to achieve environmental excellence, but also, responsible social and economic performance*” (Hes, 2003).
- **‘Beige’ Building** is a term coined in this thesis as a way of distinguishing buildings which have a distinct environmental, social and economic advantage over the status quo but are not intended to achieve the ‘excellence’ or aspire to the sustainability that Green Building does (Hes, 2003). For this reason, the principles and strategies required for Green building are applicable for ‘Beige’ Building. In a sense; ‘Beige’ can be seen as low-performance ‘Green’.

1.2 Alternative Building Offers Opportunities

Alternative buildings offer some solution to the problems associated with the current status quo of building practices. In developed countries the built environment consumes on average around 30 to 40 percent of generated energy (Kibert, 1999) or two thirds of global energy flows (Augenbroe & Pearce, 2000 In Emmanuel, 2004). In some countries this is much higher. The US building sector alone consumes two thirds of generated electricity (Kooomey, *et al.*, 2001). This represents a major proportion of anthropogenic carbon dioxide contributions to the enhanced greenhouse effect. The ‘embodied energy’ of materials, or the energy used to extract, process, transport and construct materials in a building can equal 20 to 30% of its use-phase energy demand (Planet One Sustainability Strategies & Centre for Design RMIT, 2003).

Alternative building designs can dramatically reduce the energy required to construct and use built space. Application of sustainable technologies in existing commercial buildings can reduce peak energy demand by 20% to 50% compared to conventional standards (Toshio, 2001) with some buildings making substantial improvements above this (Childs, 2005; de Blas, 2002; Planet One Sustainability Strategies & Centre for Design RMIT, 2003).

In developed countries the built environment demands 40% of all raw materials extracted (Kibert, 1999) and globally, about a sixth of all fresh water extracted and 25 % of the world’s timber harvests (Augenbroe & Pearce, 2000 In Emmanuel, 2004).

Results of real projects and research show that careful management and forethought can yield major reductions in material use on-site. Construction and demolition waste was reduced by 80% in the building of one civic centre building through careful planning and use of recycled materials (Hes, 2003; Hines, Pers. com.). Intelligent building of a house in Sweden using recycled materials enabled a 30% reduction in raw material use and 80% in synthetic chemicals (Thormark, 2000).

Many of the negative impacts from the built environment occur after construction. Demands for space heating and cooling, water heating, lighting and refrigeration form the major part of all energy used within the residential built environment. In the US, building energy services contribute approximately the same carbon emissions as Japan and Britain combined (Kooomey *et al.*, 2001). Unfortunately, building occupiers have little choice but to add to the impact their buildings have had since “*by the time the building designs are completed, most of their lifecycle economic and ecological costs have been made inevitable*” (Sibley, *et al.*, 2003). Following construction, the following 15 to 30 year life-time typically associated with modern buildings is thus a period of “*...costly and environmentally damaging operation...*” that is unnecessary and avoidable (Planet One Sustainability Strategies & Centre for Design RMIT, 2003).

Alternative buildings offer lower use-phase costs. There are numerous examples of dramatic cost reductions in new and refitted buildings resulting not only from lower material and energy consumption but also lower maintenance demands, waste generation and associated disposal costs (Abraham, 1996; Kats, 2003; Anon., 2003). Materials consumed in the buildings use-phase can also be greatly reduced; water by over 30% (Abraham, 1996) for example.

'Green' buildings bring additional positives, either as knock-on effects from other benefits or as independent qualities. Reduction in heating ventilation and air conditioning (HVAC) requirements by clever use of passive design can allow for greater useable floor space and thus bring higher rented or lease prices (Planet One Sustainability Strategies & Centre for Design RMIT, 2003). Green-building can lead to new markets (Sexton, 1997) providing additional jobs and income to non-traditional aspects of the building industry (Abraham, 1996). Toxicity levels can be greatly lowered and general health of building occupiers improved (Abraham, 1996). Even improvement of worker performance and resulting company income has been linked to Green-building (Stretch, 1997; Toshio, 2001). 'Sustainable' buildings can also translate to a strengthening of local identity by expressing community values (Chiu, 2004).

Furthermore, a shift away from the status quo in the ways described does not mean substantial cost increased over conventional buildings and any first-cost premiums generally pay back any over a few years (see for eg. Childs, 2005; Kats, 2003).

1.3 Reasons behind the Poor Adoption of 'Green' Building

The apparent dichotomy, that few alternative building techniques are adopted despite their many benefits shows many similarities with the lack of adoption of other cost effective 'environmental' technologies such as advanced energy-efficient technologies.

The most fundamental barriers affecting both the demand and supply ends of the alternative building market are believed to be high information costs, imperfect information and perverse fee structures for basic resources (Eisenberg, 2002; Institution of Engineers Australia, 2001; Landman, 1999).

The demand side of the market is more likely to meet with the problem of being caught between split incentives where the building owner who makes the decisions on building design and appliances installed, does not pay the utility costs for water and energy that are influenced by those same design and utility choices (Koomey *et al.*, 2001; Landman, 1999; Rochracher, 1999).

Supply-side players are more likely to face the problem of inertia [Novelli, Pers. com; Koomey, 2001 #118]. As numerous reports and academic studies have described, the construction industry as notoriously resistant to change (see for example (Dulaimi, *et al.*, 2002; Nicolini, *et al.*, 2001; Oster & Quigley, 1977) and characterised by antagonism and adversarial internal relationships (Koskela & Vrijhoef, 2001; Winch, 2000). This culture creates a difficult environment for building suppliers to work in 'Green' building projects which demand a fundamentally different approach; one that is inherently holistic and demands a high level of stakeholder integration (Hes, 2003). The failure to consistently apply a holistic and integrated approach in the design and construction process is one of the most common causes of failure in 'Green' building projects (Planet One Sustainability Strategies & Centre for Design RMIT, 2003).

2 Study Context: Aqaba and the ASEZ

Aqaba, population: 104 000, Latitude: 29.63^o, Longitude: 35.02^o, lies at the southern apex of Jordan, sharing land and sea borders with Egypt, Israel and Saudi Arabia. Aqaba is the primary urban centre for the Aqaba Special Economic Zone (ASEZ); a 375km² region designated in 2001 with the objective of developing into the “... *driving force for the economic growth of Jordan*” (Aqaba Special Zone Authority, N.D.) (see Fig. 2-1)

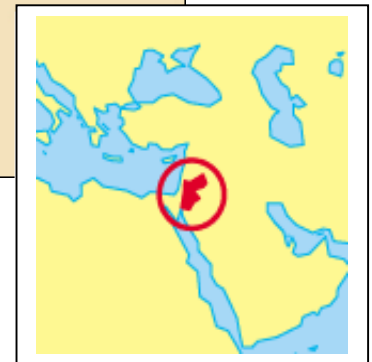


Figure 2-1 Aqaba and Jordan

NB: Refer to Appendix 1 for a detailed map of Aqaba

The ASEZ, population: 104 000, is a semi-autonomous region within Jordan. Its laws and regulations, including low flat-rate income tax, zero tariff and import taxes, no foreign equity restrictions and multi-use commercial, tourist and residential zoning are designed to facilitate rapid economic growth (Aqaba Special Zone Authority, N.D.). Specific aims of the region are challenging; to achieve a minimum €23 bn. in investment and a minimum ASEZ population of 250 000 by the year 2020 (Rousan, Pers. com.).

2.1 Challenges to Development of the Aqaba Built Environment

With the mandate to “...*transform Aqaba into a world class Red Sea business hub and leisure destination; enhancing the quality of life and prosperity of the Aqaba community through sustainable development*” (Aqaba Special Zone Authority, N.D.) and a tight timeline in which to meet specific targets, the ASEZ authority (ASEZA) faces many significant challenges to developing its built environment.

2.1.1 Mitigating Social Stress and Instability

Rapid economic growth has and will continue to place stress on the local community already dispossessed of its free access to traditional beaches, disaffected by rising prices and with little involvement in local decision making. Research has shown that communities with low levels of education and training such as in Aqaba are particularly vulnerable to being left behind by economic development particularly when this development is facilitated by a deregulated environment wherein “*the economic well-being of individuals is increasingly determined less by government than by the rapidly escalating interdependence of the world economy*” (Zhao & Zhang, 2005). Mitigating social strain as economic growth accelerates in Aqaba will require sensitive and balanced decision making that affect local housing. Economic growth has been attributed to poverty reduction (Booth, 1990; Contreras, 2001) but rapid growth has also been strongly related to increased social inequality due to disparity between rising incomes and faster rising essential service costs (Fang, *et al.*, 2002; Krongkaew & Kakwani, 2003). With compelling arguments existing that social integration and stability are reduced by income inequality (Blau, 2000; Galbraith, 1998; Glom & Lagunoff, 1996), Aqaba would do well to mitigate cost and lifestyle forces that can emerge in the built environment to facilitate social inequality. An active approach by government must be made to ensure equal access to comfortable, affordable housing services in Aqaba since market forces are unlikely to drive a reduction in housing costs; particularly with approaching resource bottlenecks.

2.1.2 Building a Sense of Identity

Expected population growth will come mainly from immigration. Thus, Aqaba faces the challenge of building and maintaining a strong identity in the face of more than doubling the population in a very short period with people having little geospatial understanding of the location and no cultural connection to it. Building a positive sense of place is important for building ‘social sustainability’ and is correlated to communities expressing “*habitual patterns of movement around familiar and significant objects*” (Hargeaves, 2004). Similarly, by Lefebvre’s theory, a sense of place is a function of its conception and designed physical form, the way it is perceived and experienced as well as how it is used on a day-to-day level (Lefebvre, 1991 in Sexton, 1997). Hargeaves (2004) also argues that a lack of distinguishing features does not correlate well with either special identity or interest in place. Putting this understanding into practice when decisions over the form of Aqaba’s built environment are made could play an important role in building a sense of loyalty, community and pride in the region; particularly with the growing immigrant population. A clear and unique local identity is also essential for a city targeting the high-end tourism market.

**“housing forms...
give identity to a
culture”** (Chiu, 2004).

2.1.3 Pursuing a Competitive Growth Path

For Aqaba to avoid becoming an indistinguishable addition to the growing numbers of sea-side resort cities globally, it must think beyond merely playing host to good hotels and offering quality service. This is not a secure road to competitiveness and success. Developing a uniquely Aqabian built environment however, one that reflects local socio-geography is a challenging step that if taken, can help Aqaba carve-out an identity separate from other resort towns in the region.

2.1.4 Adapting to Limited Resources

Aqaba has a hot and hyper arid environment with very few renewable natural resources. Annual rainfall is less than 30mm, mean minimum and maximum summer temperatures range

between 25^o and 38^o respectively and monthly summer pan evaporation rate lie between 570mm and 620mm (Aqaba Office of Meteorology, 2005). Ever-present northerly winds bring some respite from the heat but source from the hot Jordan valley and are dry (<50% humidity). Aqaba sources most of its water from a finite fossil aquifer shared with Saudi Arabia and soon to be shared with Amman (Al-Farajat, 2001; Farajat, Pers. com.). The lack of renewable water, coupled with very light sandy soils and no effective soil 'A' horizon means conventional agriculture and forestry is not feasible in the ASEZ. To meet rising water demand it is widely believed in the ASEZ that desalination offers the only solution (Al-Zaubi, Pers. com.). Jordan as a whole has been experiencing a water deficit since 1996 (Al-Jayyousi, 2003) and with most of its ground water resources at capacity or over exploited (Al-Farajat, 2001), Jordan is rapidly approaching a water crisis (Farajat, Pers. com.). Clever demand-management is needed in Aqaba to avoid an energy cost crisis when it shifts to desalination as the primary water source. Managing resource demand of the building stock will be a necessary part.

2.1.5 Accommodating a Growing Population

Aqaba's built environment must be designed to face demographic challenges. Jordan's population is predominantly urban (77%), young (36% under the age of 14), and experiencing growth of around 3.6% (Department of Statistics, 2000; Oxford Business Group, 2005). Thus, rising rates of resource consumption which saw national energy consumption growing 5% between 1998 and 1999 (Ministry of Energy and Mineral Resources, 2000 In. Jaber, *et al.*, 2003) will continue as more Jordanians reach child bearing age, build families and demand new or expanded homes. Without alternative supplies, rising demand will drive up raw material and energy prices. In Aqaba a more material and energy efficient built environment can act to moderate resource limitations and financial stress on the local population.

2.2 Potential Consequences of a Poor Built Environment

Continued expansion of the Aqaba built environment under increasing social and environmental pressures has the potential to have severe negative impacts on Aqaba's competitiveness as a business and tourist centre and to the community as a whole.

Poorly managed use of water and electricity resources will require increases to capacity early than necessary. Provision of additional fossil fuel for energy and desalination is already planned but the extent to which current resources are handled will determine when and how much additional capacity is needed. For Aqaba, this will also mean a continuing reliance on external sources of energy from outside the ASEZ.

Complete depletion of potable aquifers represents a likely possibility if the current pattern of resource demand and extraction continues. Not only will this mean an earlier shift to desalination for water provision but also the possibility of irreparably polluting aquifers by drawing in saline water from adjacent unconfined salty groundwater as water tables fall (Farajat, Pers. com.). Increased use of desalination also means greater reliance on external energy sources for a critical resource. In a region where efforts to secure energy and water resources have frequently lead to conflict, overdependence on energy supplies from outside Jordan may prove a poor strategic choice.

Increasing resource and land prices resulting from rapid investment and resource scarcity (including land and labour) has the potential to see complete marginalisation of the Aqabian poor. With the majority on or less than €225 per month and already finding it difficult to cope with water and electricity costs and the inability to purchase land (Hanna, 2005; Al-Jamal,

Shamuh, Pers. com.) the potential for future social division and a majority of the population facing ingrained poverty is high.

The opportunity to create a unique tourism destination through an interesting and innovative built environment that reflects local conditions may be lost to Aqaba. Over one third of the planned built environment already exists and there is little evidence of a uniquely Aqabian aesthetic. Aqaba may yet drift down the short-sighted path taken by numerous resort towns in Mediterranean Europe resulting in a low-quality, mainly package-tourism destination lacking any characteristics distinct from its competitors and key landmarks under increasing pressure from human impact.

2.3 Aqaba: Uniquely Placed to Spearhead Change

Aqaba is presented with some major challenges to achieving the regions' strategic objectives but it is also fortunate. The ASEZA local authority (ASEZA) has clear planning and strategic development goals by which it is able to measure success and maintain momentum. The vision encompassed by these goals takes in the expansion of Aqaba as both a commercial and tourism hub while promoting the conservation and wise-use of the natural marine environment. The region also has a clear master plan through which new development can be interpreted. Thus the potential for land-use conflict is minimised. ASEZA also has legislative autonomy in regard to dealing with development of the built environment. It can write, modify and enforce building and planning regulations and codes in order to achieve its objectives. Furthermore, the ASEZ holds expectations as the nations' 'engine for growth' and hence, ASEZA has a mandate to be bold and push boundaries in laying a path for economic development.

2.4 Unique Opportunities for Improving the Current Building Stock

A unique opportunity exists in the ASEZ to create a built environment that is truly 'Aqaba'; a built environment that is culturally sensitive to the regions' rich heritage, aesthetically and functionally adapted to the local geography, low in environmental impact and which acts to slow resource demand growth and moderate the dramatic social and economic changes affecting the ASEZ.

The opportunity exists because the majority of the built environment is yet to be conceived. While the ASEZ is not a 'clean-slate', driving change at this stage in the development of the local building stock, with rapid growth underway and increasing investment likely, presents an opportunity to rapidly advance alternative styles and quickly change the appearance and resource demand of the built environment. Similarly, the ASEZ is a changing community still in its infancy. Thus it is in a better position to resist tendencies to follow conventional paths of progress that have occurred in other regions in Jordan, it is also better able to take chances against the norm and set its own identity.

Opportunity for improvement also exists because a required 'change for the better' in the local built environment is understood by top management in ASEZA (Al-Bilal, Pers. com.). Thus the idea of change has top level commitment in the most important local institution. If necessary and other mechanisms fail, alternative building can be driven by prescriptive legislation.

Furthermore, opportunities exist in the energy and resource savings that would be made by reducing demands by the Aqaba built environment. Savings translate directly to delayed or avoided resource bottlenecks, flow-on supply constraints, conflicts over resource allocation

and social and economic stress. Expansion of energy and water supply capacity can also be delayed, allowing longer time for planning and aiding social integration and a more economically even society by reducing economic stress.

The ability to define and create a strong local identity through the built environment is a valuable opportunity. There is no evidence of any tourism or investment hub in the Middle East having been consciously designed for the environment. In being the first, Aqaba can directly improve the local economy by creating a unique marketing advantage from quality, aesthetic, environmental and technological built environmental characteristics; features that are more easily marketed for high end tourists interested in cultural and uniquely local experiences rather than package tours.

2.5 Reasons & Implications for adopting Beige-Building

If a successful improvement in the social, environmental and economic impact of the Aqaba built environment is achieved, this experience would have relevance far beyond the ASEZ borders. Being a national engine for growth, whatever happens in Aqaba directly affects and has lessons for Jordan as a whole. Jordan, like Aqaba, has no valuable tapped fossil-energy resources and is dependent on its neighbouring countries for supply (Oxford Business Group, 2005). 91% of Jordan receives less than 200mm of rain a year (Al-Jayyousi, 2003), mirroring a shortage in the ASEZ. Aqaba's handling of its own paucity of renewable water resources therefore has implications for national water management. Aqaba also reflects the nation in being home to a large majority population that are poor and vulnerable to a down turn in what has been a relatively resilient economy in the region (Oxford Business Group, 2005). The management of rapid growth in resource demand due to a rapidly growing population in the ASEZ will also provide lessons for dealing with consequences of national population growth.

Jordan has an opportunity from knowledge gained through an Aqaba experience with Beige-buildings to sell its expertise to neighbouring countries. The parallel drawn between the ASEZ and Jordan can also be made with other countries. The built environment in Saudi Arabia is also undergoing rapid change including dislocation from its natural and historical roots (Saleh, 1999). The built environment's demand for resources such as water (Saleh, 1999) is increasing, as is the replacement of natural materials for concrete (Saleh, 2000). A similar pattern has occurred in other Gulf countries with buildings shifting dramatically away from traditional materials developed for local conditions to concrete, steel and glass structures heavily reliant on air conditioning (Mahgoub, 2004; Hamouche, 2004). Kuwaiti architect Hamed Shuaib raised this issue in 1999 asking *“when will we, in Kuwait and other Gulf countries, have modern architecture suitable for our community, environment and heritage?”* (Shuaib, 1999). In reference to environment, Shuaib could have been referring to countries outside the gulf as well, for as noted by Probst, (2004) *“Modern buildings...in countries with hot climates, are seldom designed based on heat-gain criteria...”*.

The ability of how Aqaba handle its finite water supplies in the face of a rapidly growing population has implications for the whole region. With the population in the Middle East estimated to reach 600 million by 2030 and per capita water resources expected to halve (Harrison, 2004). The path which Aqaba takes in trying to create a social, economic and environmentally benign built environment will be critically important to Jordan and may hold valuable lessons for all countries with hot arid environments with limited natural resources.

3 Objectives and Methodological Approach Taken

3.1 Research Questions:

This thesis seeks to answer:

Where and how does 'Beige' Building out-perform the status quo of Aqaba residential construction?

What forces influence (promote & retard) persistence of the current built environment form?

What can be done to promote a 'positive' shift in the residential built environment toward 'Beige' Building?

3.2 Aims & Objectives

This thesis aims to assess the Aqaba residential built environment in regard to its impact on the natural, social and economic conditions in the ASEZ and offer suggestions on appropriate steps that can be taken to improve these impacts.

To achieve these aims, objectives are:

to identify the material and technical characteristics of the ASEZ residential built environment

to identify applicable building techniques applicable for hot, hyper arid conditions

to compare cost of 'preferred' techniques with the cost of status quo building

to identify barriers restricting improvement to the current status quo

to propose actions that would help mainstream the use of reduced-impact Beige-Building techniques in the built environment

3.3 Approach

Answering the research questions and achieving the aims and objectives involved the following techniques and approach.

3.3.1 On-site Data Collection

A qualitative and quantitative assessment of the Aqaba built environment was made during June and July 2005 from on-site building inspections, 'drive-by' and 'walk-by' inspections of the suburban landscape and analysis of printed and digital spatial data. On-site and 'walk-by' assessment was aided with the use of a checklist, compass and measuring tape. The checklist aided identification of characteristics such as orientation, materials and proportion of glazing to wall area considered by 'Green' building literature as critical for the environmental performance of buildings. Field studies were conducted in nine areas considered (by locals) to be representative of different social and income levels. See Appendix 1 for name and location of areas surveyed. Assessment of digital (GIS) and printed maps focused on the relationship between macro scale features of the Aqaba natural and built environment such as land gradient and direction of roads to 'micro scale' features such as orientation of streets, houses and position of buildings on plot areas.

3.3.2 Evaluation of Building Thermal Characteristics

Building envelope thermal characteristics were determined by identifying predominant construction styles and material components from on-site inspections, interviews and identifying material component thermal characteristics from literature sources. A calculation of heat transmission coefficients ‘U’ for 13 selected whole wall envelope styles and 3 roofing styles were conducted¹.

Where:

$$U_{(W/m^2K)} = 1 / (1 / f_i + x_1 / k_1 + x_2 / k_2 + x_3 / k_3 + \dots + 1 / f_o)$$

with

f_i = surface conductance for inside wall (W/m²K)

x = thickness of material (m)

k = thermal conductivity of material (W/mK)

f_o = surface conductance for outside wall (W/m²K)

3.3.3 Calculation of Cost for Construction and Cooling

Building material and construction style costs were gathered in quotes from building professionals and construction material suppliers.

Cooling costs were calculated on a single building design to evaluate the impact on cooling loads of varying material composition and orientation. A building design – prepared by local architect Abu-Afifeh was selected as the template for being typical of ‘modern’ buildings in Aqaba and for its conventional style and intended function (Pers. obs.). The building is a single storey two apartment building. It is intended as home to two families and the first floor of a low rise set of apartments (Abu-Afifeh, Pers. com.). Material composition of the building was varied using locally available materials. Three styles were used: A ‘base’ case, representing the conventional use of materials in buildings of its kind in Aqaba; a ‘minor-improvements’ case that mirrors a few rare residences in which insulation is included and an ‘advanced’ case that uses a combination of materials not yet applied in Aqaba. Basic details of the three building variations are seen in Table 3-1. (Next page)

¹ Thermal conductivity values used in the calculations of wall values and sources for these values are detailed in Appendices 2 & 3

Table 3-1 Characteristics of test buildings assessed for thermal performance

Scenario	Windows	Walls	Roof construction
Base Case	Single glazed with internal shading U-value: 4.6 ¹	2cm Pl : 1x20cm HB : 10cm C : 5cm Lst U-value: 2.01	2cm plaster + 20 cm Hollow block + 5cm concrete U-value: 1.77
Minor Improvement Case		2cm Pl : 2 x10cm HB : 2cm Air : 3cm P : 10cm C : 5cm L st U-value: 0.528	
Advanced Case	Same as above but double glazed with 100% opaque external shading U-value: 3.12	40cm StwB : 16mm C Render : steel reinforcing mesh U-value: .242	2cm Pl, 20cm HB, 5cm P, 5cm aerated concrete, U-value: 0.456
Additional Characteristics of all designs			
Floor area & roof area: 212 m ² ; Total air volume: 667.5m ³ Internal loads: 10 persons @ 67 W + 940 W for appliances and lights			

NB: Where, Pl = Plaster; HB = Hollow block; C = Solid aggregate concrete; P = Expanded Polystyrene; Gr = Uncut granite stone; Air = Unventilated air gap; L st = Limestone; StwB = 3 string straw bale; U is in (W/m²K)

Peak cooling loads were calculated by hand to determine air conditioning requirements. Split-air-to-air units were used in the calculation. Details and costs were obtained from a local air conditioning firm Petra Engineering. Procedures and assumptions for residential heating and cooling followed those set out in ASHRAE, (1997). This method focuses mainly on characteristics of the building envelope but takes into account orientation, temperature and ventilation conditions. (Assumptions and detail of the buildings are listed in Appendix 4.)

Calculation of average monthly cooling loads followed a method in which:

$$\text{Total monthly cooling load} = \text{total monthly heat gain} / \text{COP} \quad (3^2)$$

Where heat gain $Q_t = q_{\text{conduction}} + q_{\text{ventilation}} + q_{\text{internal-load}} + q_{\text{solar-gain}}$

In calculating heat gain, solar gain included only gain through windows. Calculation of solar gain was made using an online calculator (Gronbeck, 1999) which took into account latitude, ground reflectance and percentage of clear days. As a result of excluding solar heat gain through walls, final heat gain figures will be lower than in-reality for each building. Thus, lower recorded cooling costs for all buildings will be also be lower than reality; particularly for

¹ Window U-values were taken from (ASHRAE, 1997)

² The coefficient of performance (COP) of the split air-to-air conditioning units was assumed as 3, based on estimates given by Khrisat (Pers. com.) of Petra Engineering

the better insulated building styles. Since the objective of this particular experiment was to determine the benefit (in reduced cooling costs) of using better thermal performing materials, results showing any benefits from using these materials will thus be conservative. Electricity prices are based on current tariffs set by Aqaba's Electricity Distribution Company (Al-Hakim, Pers. com).

The use of sophisticated modelling software for calculating cooling loads was considered but abandoned. The variation in quality of construction seen in Aqaba, combined with behavioural habits of Aqaba residents such as placing air-conditioners in or directly adjacent to open windows and failing to draw blinds or close doors during hot days (Pers. obs.) meant that the additional cooling load 'accuracy' obtained through use of software was effectively meaningless since these behavioural factors can not be factored into calculations. The time needed to gain sufficient proficiency in the software was another factor against its use.

3.3.4 Interviews

Conducting interviews during June and July 2005 was the primary method for identifying:

- *costs of labour and building materials*
- *normative perceptions of the current and alternative built styles*
- *contextual barriers to change*

Phone, email and face-to-face interviews were made with professionals and academics in Jordan, The United States and Australia. The majority of interviews were made face-to-face in Aqaba and Amman (Jordan) and followed two forms: qualitative and semi-structured. A qualitative or exploratory approach was taken in a minority of situations where circumstances such as time and contextual factors (eg. interviewee on-site work requirements) or interviewee attitudes (hesitancy to be interviewed) prevented more formal questioning. The majority of interviews were semi-structured; following defined themes and pre-determined questions.

Most interviews were made in the interviewees' non-native language. Thus considerable flexibility had to be incorporated into the delivery of questions and a set of printed pictures were often used to convey concepts of alternative building styles. Depending on the interviewee's level of education and spoken English proficiency, words, sentence complexity and even presentation of core concepts used in interviews had to be adapted. Interview strategy also changed over the two month period depending on the character of the interviewee. An initial strategy, typified by a formal and direct, checklist-style approach proved counter productive to garnering trust and eliciting information. A level of informality, including additional 'priming' questions was therefore necessary.

Interviewees in Jordan were selected based on their contrasting roles and influence on the built environment. Interviewees were conducted with employees with Non Governmental Organisations (NGO's), regional and national authorities, building industry representatives, professional associations, building professionals, material and hardware suppliers, investors, real estate agents, banks and Aqaba residents. [see Appendix 5 for a list of interviewees]. On-the-spot discussions with Aqaba residents were also made in the City centre area and Shallalah districts. These 'in-street' settings attracted many bystanders; some of whom participated in discussions. Many comments were translated. These conditions did not allow formal interviews and people were reluctant to provide their names. However, results are extremely

valuable for obtaining views and figures that are more representative of the majority ‘non-professional’ population. These interviewees are referred to in-text as ‘*Vox Pop*’.

3.3.5 Analysis of Interviews

Interview results were analysed to identify forces that influence decision making in the markets and institutions that shape the built environment. Phenomena identified were categorised into four clusters highlighting the variety of pressures observed.

- Normative forces, such as behavioural norms, attitudes and perceptions
- Coercive pressures such as laws, regulations and enforced procedures
- Utilitarian or cost incentive factors
- Capacity levels held by stakeholders shaping the built environment

Phenomena were then analysed against their impact on the ease of diffusion of Beige-building techniques. This analysis was framed around five characteristics important for the diffusion of innovations. Since the position was taken that bringing ‘Beige’ Building into the Aqaba building industry involved the “*search for and discovery, experimentation, development imitation and adoption of new products, new processes and new organisational set-ups*”, it was considered an innovation in the Aqaba context (Dosi, 1988; Porter, 1990 In Wonglimpiyarat, 2005).

Diffusion of innovation theory offers a framework for understanding the propagation of Beige-buildings as innovations and is thus of value for identifying potential mechanisms for promoting Beige-building in Aqaba.

According to Rogers, (1995 & 2002) the rate at which an innovation spreads is dependent on

- **Perceived Advantage:** The degree to which an alternative is perceived as better than the status quo
- **Perceived Consistency:** The degree to which an alternative is perceived to be consistent with the “*values, past experiences and needs of potential adopters*” (Rogers, 2002)
- **Observability:** The degree to which an alternative is visible to other potentially influencing players
- **Trialability:** The ease with which an innovation can be trialled
- **Perceived Complexity:** The perceived complexity of an alternative

Concepts from institutional theory were also drawn on to explain entrenched behaviours of major stakeholders in Aqaba that appeared to both enforce the status quo and undermine the qualities needed for better innovation diffusion. For as noted by Clemens & Cook, (1999) “*The patterning of social life is not produced solely by the aggregation of individual and organizational behaviour but also by institutions that structure action*”. The ‘patterning’ of Aqaba’s built environment and the attitudes held by stakeholders that shape this built environment are seen as no exception.

4 Review of applied techniques for influencing building impacts

This chapter outlines options available for reducing the resource and material intensity of the built environment. Given the great depth of research on low impact building, this review of literature highlights examples chosen for their general applicability to urban residential environments in hot and arid regions. It is not an exhaustive list of the myriad techniques, add-on 'nick-knacks', products and innovations that exist for better environmental building performance. So many exist and although many of these can and should play a significant part in reducing impacts, it would take more than this thesis to just describe them. An emphasis is placed on describing 'low-tech', low-cost and primarily conventional techniques, designs and tools that aspire to the following principles, considered fundamental to building in a more socially, environmentally and economically sensitive way: Using material and energy resources efficiently, using locally sourced and renewable materials and improving the liveability of the built environment (Organisation for Economic Co-operation and Development, 2002). The essential message here is that dramatic changes in energy and water demands of buildings do not require a dramatic re-think of what buildings are or even what they are made of. Consideration is however given to a few novel answers to energy demand in homes and mechanisms used to promote sustainability in the built environment are also described.

“The interaction of a site's climate, resources and attributes creates patterns and processes to which the building and its inhabitants are undeniably linked” (Gilhholey, 2003)

4.1 Minimising Water Wastage

Minimisation and recycling are two key principles to reducing environmental impact from using water in the built environment.

Minimisation is best achieved by behavioural changes. Reducing showers, not leaving taps running or washing the family car can deliver substantial savings to a homes' water consumption. Fixed water consumption rates are more easily reduced by using water fixtures such as low-flow taps, shower heads and toilets etc.

“We're increasingly putting our buildings in places where there is not an abundance of water, and we're doing it with...a blind eye...” (Shin, In Weisenberger, 2004)

In the US, low-flow add-ons have the potential to reduce water usage by 20% if applied wholesale (Weisenberger, 2004) and similar (20%) reductions from the standard consumption rate are expected in Taiwan, where green building projects have combined domestic rainwater collection with low-flow devices (Cheng, 2003). Cutting water used for human waste can bring further reductions; particularly in many industrialized countries where use of flush toilets and bathing demands 35% to 50% of a homes use (Al-Jayyousi, 2003; Cheng, 2003). The shift from flushing to waterless toilet systems can thus achieve dramatic water saving results. Cultural norms often prevent the widespread adoption of waterless toilets or urinals although awareness is more often one of the main barriers here (Novicell, Pers. com). Re-use of water also promises great reductions and is often avoided due to people's perceptions of reclaimed water as unclean.

According to (Al-Jayyousi, 2003) re-use of all domestic 'waste'-water is possible but its treatment depends on the origin and intended re-use. Re-use of 'blackwater' (sewage) involves far more treatment than 'greywater' and is rarely seen in the domestic setting. Greywater reuse

offers the greatest opportunity for domestic water saving (Al-Jayyousi, 2003) and depending on the application may not need more treatment than physical filtration (eg. for irrigation) (Water Conservation alliance of Southern Arizona, N.D.; Al-Jayyousi, 2003). Large scale residential settings have been using reuse for toilet flushing in Germany since the 1980's (Nolde, 2000) and commercially available systems have been available in Australia as early as 1981 (Neal, 1996). Re-use of grey-water not only reduces consumption of sweet-water but also helps reduce treatment costs, can reduce pollution levels and help reduce water consumption overall. According to (Al-Jayyousi, 2003) shower, bathroom sink, and laundry water make-up 40% to 50% of residential wastewater. Thus volumes of water available for reuse are substantial and can be used in various applications. After re-use in toilets, it can again be used for irrigation and even ground water recharge.

4.2 Passive Cooling

This chapter deals exclusively with reducing energy for residential cooling and mainly focuses on passive (non-powered) techniques. Passive cooling involves controlling the flows of heat through integration of design and architectural features of a building with the surrounding environment. It is based on two simple principles: rejecting and minimising heat gain (Etzion, et al., 1997; Zogou & Stamatelos, 1998).

4.2.1 Minimising Heat Gain

Heat gain to buildings from external sources is derived primarily from solar energy to walls and roof (Said & Abdelrahman, 1989). Thus heat gain can be reduced by increasing reflectance and shading of external surfaces, reducing solar gain through selective orientation, minimising input via 'thermal bridges' (un-insulated gaps) in the building envelope, by reducing heat transfer with thermal resistant materials or by slowing and modulating energy gain with materials of high thermal mass (Baker & Steemers, 2000; Etzion *et al.*, 1997; Papadopoulos & Axarli, 1992; Saleh, *et al.*, 2004). By some estimates, the difference in energy required to maintain a comfortable internal building temperature can vary by as much as five times depending on how design and energy services are selected and utilised (Baker & Steemers, 2000).

Ensuring the building envelope is resistant to the transfer, of solar energy is essential. This does not demand dramatic shifts away from the conventional building styles; merely intelligent usage of design and materials. For example, conventional building materials (eg. concrete and polystyrene), double glazing and careful choice of design and orientation has been used to maintain comfortable indoor conditions of 23 – 26 °C without the use of air conditioning even in summer in southern Israel (Etzion, 1994).

Insulation

Insulating the building envelope reduces cooling loads. Studies in Oman indicate that the simplest way to make the greatest reduction in cooling loads at latitudes similar to Aqaba (approx 29°N) is through use of insulation to the roof of buildings. Thermal gain to roof areas is significantly more than gain through walls in arid climates and Mediterranean latitudes; around twice as much as the gain to south facing walls and 1.5 times the gain to east or west facing walls (Papadopoulos & Axarli, 1992 In Eumorfopoulou & Aravantinos, 1998). Working with a test building, Zurigat, *et al.*, (2003) found a 12.7% reduction in cooling load could be reduced by adding 25mm of polystyrene insulation to the existing 25mm layer. Similarly, Al-Sanea, (2002), conducting experiments under urban summer conditions in Riyadh (Saudi Arabia) recorded a dramatic 68% reduction in heat transfer load to internal air space

compared to a control roof structure of standard design when 50mm of polystyrene was added.

Solar and Wind Orientation

Passive design involves intelligent integration of natural site characteristics such as orientation, wind and diurnal temperature fluctuations with building design and can “...*significantly reduce the need for expensive mechanical heating and cooling*” (Sustainable Energy Victoria, 2004).

As (Beckman, N.D In Runsheng *et al.*, 2003) notes “*The solar absorbance of a surface depends on the incidence angle of solar rays and the properties of the surface*”; thus reflective surfaces are ideal for minimising energy absorbance but can also pose significant problems from glare .

Solar gain can be reduced by factoring in annual changes in solar angle of incidence at the building design stage. At Aqaba latitudes, thermal heat gain from the southern aspect is minimal in summer compared to east and west aspects where solar gain is highest (Etzion *et al.*, 1997; Rousan & Shariah, 1996). For this reason, minimal breaks (doors and windows) in the building envelope to the east and west are ideal as is primary use of glazing on southerly aspects. In this way, winter heat gain is permitted when the sun is lower in the sky, without making substantial contributions to heat gain in summer when solar angle of incidence is much higher (Al-Asir, 2004; Baker & Steemers, 2000; Rousan & Shariah, 1996).

Regardless of direction, it must be also noted as a principle: Ideally, buildings in hot dry climates should have as small a surface area to volume ratio as possible to maximise thermal difference between internal and external environments (Meir, *et al.* , 1996). Furthermore, as argued by Etzion, (1994), building orientation not need to be compromised if the building is sufficiently insulated and sealed. Windows form the main heat transfer bridge however and this must be recognised in their placement.

Under hot non-equatorial conditions in the northern hemisphere, clear reductions in the cooling load (and heating load) of buildings can be gained through proper orientation of glazing. Measurements of heat gain from windows in Shiraz – Iran; latitude 29.6° N showed that in winter, south facing windows provided the only sources of overall heat gain while in summer provided minimum gain from the sun (Raessi & Taheri, 1998). Similar results have been noted by (Rousan & Shariah, 1996) across three sites in Jordan.

Windows are typically the most significant thermal bridge in building envelopes as glass transmits both heat relatively easily (Integrated Teaching and Learning Laboratory, N.D.). Reducing the window to wall ratio is the most effective way of reducing solar gain from fenestration. Ander, (2003) argues that a ratio of greater than 0.18 is unnecessary from the point of view of ‘daylighting’ since an increase in this ratio in hot climates will raise cooling load without significant lighting improvements. Adding air-gaps between layers of glass, (standard practice in many cold temperate countries) will dramatically reduce thermal transfer. (Rousan & Shariah, 1996) showed that, compared to standard single glazing windows which were calculated to allow a thermal gain of approx. 170 MJ/m²/year to a modelled building in Aqaba, double glazing could reduce thermal gain to almost half (around 90 MJ/m²/year). Further reductions of about 30MJ/m²/year were achieved using triple glazing suggesting that double glazing was far more cost effective than triple glazing. Similar conclusions are made by Zurigat *et al.*, (2003) from experiments made in Oman. Here peak cooling loads in school buildings were reduced 5.5% by swapping single for double glazing with further reductions of 2.2% gained by use of triple glazing.

Shading

Shading the external building surface is a highly effective way of reducing thermal gain. This can be done via use of vegetation (focus of a later chapter), or using simple shading devices to shield the building envelope. For example, creating 50% shade using cloth, on a roof in Oman resulted in 15.5% reductions in peak cooling loads¹ (Zurigat *et al.*, 2003).

Shading and shuttering of windows is also effective in minimising thermal gain and reducing cooling loads in buildings (Etzion, 1994; Gomez-Munoz & Porta-Gandara, 2003). Cooling load reductions up to 11% by using both internal and external shading of window areas have been recorded in Oman (Zurigat *et al.*, 2003). Similar results were modelled on a house in Iran at the same latitude as Aqaba (Lat 29.6°N) when external shading of windows was calculated to reduce summer cooling loads by up to 12.7% (Raeissi & Taheri, 1998). In this case, shading of windows on the south and north by overhangs did not prove effective at reducing heat gain in summer while substantially reduced heat gain in winter (Raeissi & Taheri, 1998). Rousan & Shariah, (1996) however, did note that a reduction in heat gain through southern facing windows was measured in summer when recessed by 15cm. Further emphasising the importance of north south orientation, Raeissi & Taheri, (1998) showed that overhangs were more effective at reducing heat gain when used on east and west facing windows.

Urban geometry can play a role in influencing urban heat gain through regulation of shading and ventilation. In urban conditions typified by high building height to street width ratios, substantial shading can be provided for all but the few hours of midday sun, through north-south orientation of streets (Bourbia & Awbi, 2004). This can act to substantially reduce heat gain by day but may also have the negative effect of retaining heat by night relative to wide streets (Bourbia & Awbi, 2004). The use of trees on wider streets has been shown to have positive impact on cooling through shading (Bourbia & Awbi, 2004; Masmoudi & Mazouz, 2004) while densely clustered buildings will reduce the ratio of sun exposed surface area to living area space.

Roof Design

Greater adaptation of building design must be made to minimise thermal gain from the roof which as a single surface, is responsible for greatest solar thermal gain through infiltration and conduction (Papadopoulos & Axarli, 1992 In Eumorfopoulou & Aravantinos, 1998). Nahar *et al.* (1999) have shown that up to 50% of a buildings total heat load in arid areas is from the roof.

Roof shape offers promise for passive cooling through design. One technique used in Israel has been to tilt roof angle (20° South). This was able to increase reflectance during periods of the summer day when solar incidence peaked (Etzion *et al.*, 1997). Other, traditional techniques have used domes and vaults. These have various advantages although authors have expressed differing opinions over their benefits. Dome roofs for example, absorb more radiation than flat roofs (Runsheng *et al.*, 2003) but receive less solar energy than flat roofs in summer months due to their auto-shading properties (Gomez-Munoz, Porta-Gandara, & Heard, 2003). Furthermore, the added vertical volume gained by dome roofing allows better stratification of hot and cold air in buildings, keeping air temperatures at lower heights more comfortable (Runsheng *et al.*, 2003). Modelling by Tang, *et al.*, (2003) also found that domed roofs absorb more heat but proved that they are also more efficient in transmitting heat and when used can make buildings more energy efficient than flat roofed (air conditioned) houses

¹ Cooling load = the amount of energy required to cool a building to a desired temperature

in hot dry conditions and provided roof angles are sufficiently steep. Furthermore, their ability to shed dust easier means that they can maintain greater reflectance than flat roofs in dusty environments (Runsheng et al., 2003).

4.2.2 Maximising Heat Rejection

Once buildings exceed thermal comfort levels, minimising additional heat gain will make no improvement to internal conditions. Maximising ventilation via convection or taking advantage of wind for evaporation are key methods for achieving passive cooling.

Ventilation

A standard approach to ventilation is to allow intake of air at low points in the buildings exterior and providing vents near the building apex. Ventilation can be improved by use of domed, vaulted or arched roofing styles with openings at the apex which are significantly better for ventilation than flat roofed buildings (Bahdori & Haghghat, 1985). These provide a space for hot air to collect and stratify above the living space while providing an outlet for the warmest air at the top (Izadpanah & Zareie, 2005). When combined with air inlets at the bottom of a building, the combination of inlet and outlet in this form creates a constant circulation from high pressure to low pressure. Placing apex vents open down wind of prevailing breezes to maximise effect of cross ventilation can further assist rejection of built up heat (Etzion et al., 1997).

Clever orientation can maximise use of prevailing winds to provide both heat rejection as well as evaporative cooling. For evaporative cooling to be effective, incoming air must have a lower relative humidity however. Etzion et al., (1997) describes the use of North-South window building and orientation in the Negev desert (Israel) where dry summer winds are northerly. Using small north windows (to minimise heat loss in winter) and larger southern ones he was able to channel the prevailing winds and improve cooling through cross ventilation.

In the urban setting, orientation to wind is even more important because compact urban forms even of low-rise buildings can reduce air flow resulting in concentration of warm static air. Parallel street-to-wind orientation has the preferred effect of channelling winds through street canyons (Pearlmutter, 1998).

Cooling Towers

Down draft cooling towers offer far better results for cooling building space than ventilation (Pearlmutter, et al., 1996). Traditional cooling towers (that evolved in Persia), involved tall hollow structures designed to capture and channel prevailing winds down into building. When combined with water to provide evaporative cooling they are able to substantially reduce temperatures within buildings when used under conditions of low humidity. Cooling in this process is both a function of incoming wind speed and the relative humidity between incoming and out-flowing air as well as the temperature difference between air and water temperature (Etzion et al., 1997; Pearlmutter et al., 1996). Modern and more technically advanced cooling towers have improved both characteristics by employing water spray systems and curved inlet wind reflectors (or mechanical fans) (Pearlmutter et al., 1996; Rodriguez, et al., 1991). Traditional variations of the theme, involve wind being channelled underground prior to entering a house in the basement or channelling air over pools or past fountains as it enters the house (Fathy, 1986; Izadpanah & Zareie, 2005).

Modelling has shown that a 4m high cooling tower of 1m cross section employing an evaporative system based on saturated ceramic channels in the most arid regions of Jordan can reduce air temperatures by 11 °C, providing the equivalent of about 1ton conventional cooling capacity (Badran, 2003). Pearlmutter et al., (1996) achieved approximately 100KW (approx 28.5ton) of cooling power for a 500m² glazed courtyard in similar wind, temperature and humidity conditions using a 10m high, 3.75m² diameter downdraft cooling tower in the Negev desert. This was achieved using approx 1-2m³ water sprayed per day and fan forced air. In the opinion of (Sanchez, et al., 2002) requirements for wind speed generally make natural draft cooling towers un economical since they must accommodate large air volumes to achieve significant cooling and this means larger units.

4.3 Active Cooling with Geothermal Heat Exchange

Various techniques offer promise to the idea of active cooling without requiring all the fossil fuels and refrigerants traditionally associated with powered cooling devices. Without going into excessive technical detail, the principles and advantages of geothermal heat exchange as a cooling option is explained.

Geothermal cooling works on exactly the same principles as split unit air conditioners requiring essentially three components: a heat pump to extract heat from the building, a heat exchange system for removing extracted heat and a distribution system for transferring cool air around a building.

The heat pump operates in the same way as a conventional pump except that heat energy is transferred to a liquid medium (such as water) which is circulating through pipes imbedded in the ground or a nearby water body. Thus to work as a cooling system, ground or water temperatures must be lower than ambient air temperatures.

Geothermal heat exchange offers the following advantages:

- It is effective: Geothermal heat exchange can provide up to 400 tons of cooling per acre of pipes if laid vertically (as opposed to horizontally) into the ground (Cook, 2000).
- It is cheap to run and has lower maintenance costs than conventional heating and cooling systems: Geothermal heat exchangers in the US can bring between 40 -70% savings on conventional heating or cooling and have a pay back time typically within five years for large scale building applications. Furthermore maintenance costs are usually between \$0.12 and \$.15 per square foot compared to costs for conventional systems which cost between \$0.3 to \$0.35 per square foot (Madsen, 2002).
- It can work as both a heating and cooling device: Provided ground or water temperatures are warmer in winter and cooler in summer than ambient temperatures.
- They are durable: Life expectancy is in the order of 20 to 50 years (Madsen, 2002).

BUT! They are also expensive to install: Geothermal cooling systems typically cost from 10 to 15 times more to install than conventional cooling systems and thus they are more applicable to long-term owner-occupiers such as municipalities, schools and commercial head quarters (Cook, 2000).

4.4 Material Choice

Careful material choice in buildings can play an important role in reducing built environment impacts on the environment. (Abraham, 1996) recommends that materials' 'embodied energy'¹ and life-cycle impact should be taken into account when trying to select materials. Despite the collation and publishing of information on material life-cycle properties by various institutions (eg. the Resource for Environmental Design Index - REDI), the average contractor may find life-cycle assessment difficult to determine. Abraham, (1996) makes other suggestions, commenting that the reduce-reuse-recycle *modus operandi* should guide decisions and actions on materials. Other practitioners make similar assessments and add that maintenance requirements should also be considered when selecting materials (eg. Anon., 1997).

Some materials have better environmental properties and are particularly suitable for hot dry conditions. These materials are those that improve building thermal qualities while also having lower embodied energy than alternatives. For some regions, wood must be transported a long way, may be expensive and is thus not a very good material environmentally (Norton, 1998). Materials with high thermal mass (high heat capacity) are ideal in hot conditions that have high diurnal fluctuations (more than 14 °C between day and night) (Pearlmutter & Meir, 1995). The delay in heat transfer can mean that air conditioning is not required during normal hours but possibly in the evening. This is the situation in compacted (rammed) earth constructions in Arizona (Nye, 2004a). Rammed-earth constructions in hot-dry areas are thus ideal for day-time occupied buildings (Taylor & Luther, 2004) such as government Offices, schools or civic centres. Limiting thermal input via glazing and roofing play a major role in increasing the effectiveness of high thermal mass materials to maintain comfort levels in the building.

Provided they are used in sufficient thickness, high thermal mass materials such as concrete and earth slow heat transmission so that heat gain to the internal space from incident solar radiation is delayed until night when temperatures have fallen dramatically. The problem with concrete however, is that it has a very high embodied energy. In comparing energy demand for various construction materials Venkatarama et al., (2003) measured a single hollow concrete block of typical dimensions (40x20x20cm) as having an embodied energy content of 15MJ (with 10% cement content). This was considerably greater than their measurement of cement stabilised earth blocks (with better load bearing capabilities) at 3.5MJ. Building with earth has other positive qualities: it is usually available on site, reduces the need for importing and transporting materials and reflects local colours of the landscape. Using a lifecycle approach to determine an Environmental Suitability Index of various construction materials, (Emmanuel, 2004) found rammed earth and 'wattle and daub' to perform better than brick and concrete blocks.

Earth is not always ideal in hot dry conditions however as it has low thermal resistance (CSIRO, 2000) (meaning that heat will eventually pass through), requires a specific range of clay to aggregates to work well and its' high thermal mass can be a disadvantage when diurnal fluctuations are not high (Norton, 1998). In these instances, there is not a large enough temperature gradient between night-time indoor and out door temperatures to draw heat back out. Under these conditions, high thermal resistance is preferred over thermal mass. Suitable materials include the use of straw as a wall-filler (Novicel; Novelli, Pers. com) which provides very good thermal resistance (Amazon Nails, 2001; Nye, 2004b). Other materials also show promise. 'Papercrete' for example; a high thermal resistance building material that is lightweight, utilises waste paper and cardboard is very cheap and has been used in the US at

¹ Embodied energy of a material is the sum of all energy required to generate, transport to site and construct with a material. It generally does not include solar or human energy requirements.

costs in the range of \$8.0/m² (Solberg, 2002). Caste earth – a method utilising a liquid gypsum-soil mix is perhaps one of the most promising. It has the thermal characteristics of rammed earth but its liquid nature (when unset) means it can also incorporate insulation within it; something other solid earth walls cannot do. Furthermore, the gypsum within it allows a wider range of soils to be used (Anon., 2004).

4.5 Plants and Landscaping

Landscaping can be used to both minimise heat gain and increase evaporative cooling. Studies have shown that in a hot and dry urban environment, the presence and position of vegetation makes a ‘considerable’ difference to thermal comfort (Masmoudi & Mazouz, 2004). Using shade trees can reduce temperatures in buildings and in external living areas for example (Shashua-Bar & Hoffman, 2004). Planting over roof areas also provides benefits through blocking solar gain and reducing daily temperature fluctuations (Eumorfopoulou & Aravantinos, 1998). Courtyards in hot dry landscapes can also create cooler microclimates but care must be taken to ensure sufficient ventilation and minimise solar gain (Etzion, 1990; Safarzadeh & Bahadori, 2005). Conscious use of orientation can also control ventilation from wind and provide shade (Meir, Pearlmutter, & Etzion, 1995).

Earth insulated walls provide another example of how landscaping can reduce heating and cooling loads on buildings in hot dry climates by reducing energy gain and energy loss from the building. In a similar way to high thermal mass walls, earth sheltering also increases the ‘thermal inertia’ (heat storage capacity) of a building, reducing temperature fluctuations (Etzion et al., 1997). Earth sheltering can provide substantial cooling even in summer without insulation Sabotka, et al., (1996).

4.6 Cost of ‘Green’ Buildings

With all their potential, green buildings are still a minority and integration of the techniques described in the chapter so far remains on the fringe of conventional building. Is cost the issue? Numerous case studies, reports and commissions have all ended up with similar conclusions to this question:

Green buildings do not demand significantly higher first-costs than conventional buildings and more than pay for any extra investment via the buildings use *if the right approach is taken to design and construction.*

A study of LEED¹ accredited buildings in the US in the late 1990’s indicated that increases in construction costs of 2.5-7% above standard levels were found for buildings achieving various levels of ‘green performance’ (Steven Winter Associates, 2002) In (Anon., 2003). However, no additional costs were necessary at lower levels of LEED accreditation if guidelines were followed strictly (Steven Winter Associates, 2004).

In an another extensive analysis of Green building costs, a report for the Californian sustainable building task force Kats, (2003) found that “...*minimal increases in upfront costs of 0-2% (or \$3 - \$5 per square foot) to support green design will result in life cycle savings of 20% of total construction costs -- more than ten times the initial investment.*”

¹ Leadership in Energy and Environmental design (LEED) is an environmental accreditation and labelling scheme for buildings. It is an industry driven initiative that originated in the US. It has now been adopted by other countries (Building Design & Construction, 2003).

Numerous case studies back this up. For example, Planning Design Build hypothetically remodelled a recently completed high-rise office building to meet LEED gold rating standards and found a cost premium of around \$40/m² or an equivalent of \$5/m² per year extra in rent. The buildings holistic designs resulted in around \$10/m² per year reduction in running costs (Anon., 2005b).

4.6.1 Issues that influence the cost of ‘Green’ Buildings

“effective sustainable design requires participation from the entire building team”

Despite the good news, many attempts ‘green building’ attempts are over budget and not very successful. A common thread between many green building experiences is that costs and reduction of impacts are consistently linked with the degree to which environmental principles were incorporated early in the design process (McLennan & Rumsey, 2003; Ngowi, 2001) and stakeholders are integrated in the conception and construction processes. As noted by (McLennan & Rumsey, 2003) the primary variable in first costs for Green buildings is the skill, attention and commitment of the design team. Likewise, Toshio, (2001) states that “...*effective sustainable design requires participation from the entire building team, including the owner and government agencies*”.

Poor understanding of alternative technologies by the building industry can have a dramatic impact on cost. Lack of skill and experience with materials and integration of techniques has contributed not only pushed up costs on projects it has also lead to many ‘failures’ in application of green buildings contributing to the public perception that building for the environment requires a high cost premium. Typical failures from lack of experience generally involve poor integration of different techniques and an ‘add-on’ approach to building sustainably. The result has been unnecessary cost blow outs on many projects using ‘Green’ features and even higher risk aversion to ‘Green’ among a generally conservative construction industry (Institution of Engineers Australia, 2001; Okraglik & Pollard, 1995; Novelli, pers. com.).

The shift in the current system of beliefs and values required to change the built environment fundamentally will rely on clever use of existing materials, designs and building principles rather than the embrace of new technologies. As experienced in a large Green-building project in Botswana, “*Although the building practices that were employed are not new, the fit among them made the difference*” (Ngowi, 2001).

In the US a systemic lack of knowledge of Green-building means important players in the building market like insurance agencies and banks are not able to assess the worth of ‘Green’ (Anon., 2003).

In addition to these strategic problems, the low demand for green buildings themselves can affect building prices. Often materials used are low in demand and thus more costly by nature of their small scale production. In addition to limited production, costs can be greater where materials require specialised distribution, developmental shifts in company processes or in cases where firms decide to internalise environmental costs previously not borne by society (Malin, 2000).

4.7 Mechanisms for Promoting the Diffusion of Beige Building

Various measures have been taken by institutions to promote the spread of more Beige buildings. The following sub-sections outline examples of three styles of mechanisms taken from around the world and points to their effectiveness as tools.

4.7.1 Command & Control Methods

Prescriptive methods of ensuring building environmental performance often appear in the form of minimum acceptable standards. In this approach, specific characteristics such as thermal resistance values of the building envelope or flow rates of fixtures are defined.

Canada (1999) and Mexico (2001) for example have issued building codes which mandate energy performance levels on buildings. Mexico's follows the common approach (also used in California and Australia) where minimum whole wall U-values are prescribed (Probst, 2004). Canada's system is more complicated, allowing contractors some level of flexibility on energy performance, but minimum standards are still required, they just depending on building circumstances. In the opinion of (Lee & Yik, 2004) it is this complexity of calculating case-specific energy performance requirements combined with and the low price of energy that has slowed momentum in the direction of building energy performance.

On the other hand, broad sweeping minimum standards suffer from the problem of site sensitivity if applied across wide jurisdictions. Erell, et al., (2003) discusses the use of zoning building requirements to climatic conditions. Since human comfort and cooling loads are not based on single criteria such as temperature, building codes must therefore also be based on a range of climatic data. Israel for example, have recently considered mean daily temperatures, daily temperature fluctuations, solar radiation and average relative humidity for their mapping of theoretical building zones (Erell et al., 2003).

The prescriptive approach to environmental improvements in building also faces the problem with trying to guide a notoriously conservative and inert industry (Dulaimi et al., 2002). This appears to be the case in Hong Kong, which implemented a range of challenging building codes aimed at dramatically reducing energy demand through mandatory requirements. According to (Lee & Yik, 2004), this has gained only slight improvements in building energy performance due mainly to industry resistance to prescriptive mechanisms. Other criticisms to be considered are that mandatory as opposed to performance orientated energy requirements are too inflexible and that in the Hong Kong case, a whole new administrative arm was required to regulate their implementation (Lee & Yik, 2004).

In some cases, minimum standards restricted better environmental performance. In Arizona, significant reductions in technical and sanitation licensing requirements were made to laws regulating grey-water reuse after it was shown that many people reused grey-water without licences and without any negative impacts (Little, 2001).

When using a strict regulatory approach, often the highest standards that can be prescribed are simply the level of performance allowed by existing of information barriers. Minimum standards do not provide incentive for continuous self improvement and they don't deal very well with the issue of split incentives. A common problem with leased or rented buildings in which building developers or building owners make choices which affect the efficiency of electricity and water consumption and leave the tenants to pay the affected bills (Blair et al., 2003).

4.7.2 Incentive Methods

Incentive mechanisms for improving environmental improvement in the built environment are incredibly diverse.

Traditional incentives have followed the rebate or subsidy route with varying success. In the US, where rebates on energy efficient technologies have been offered since the early 1990's, savings have been significant (Yik & Lee, 2004). Not so in Hong Kong where similar incentives produced less than a 0.25% drop in energy consumption (Yik & Lee, 2004). Variations on this theme include a scheme recently introduced used in Canada. Here, building owners are offered a cash bonus if their building achieves a 25% increase in energy savings above minimum code standards (Lee & Yik, 2004).

Adjusting price and pricing of household resources such as water has proved effective in reducing consumption. According to Walski, et al. (1985), price is more effective lever in reducing peoples' water consumption than other measures such educational programs or conservation techniques. Replacing flat rate charges with volumetric water pricing led to major reductions in household water consumption in many countries including Spain, Abu Dhabi and Greece (Abu Qdais & Al Nassay, 2001).

More innovative government incentives such as offering rapid building approval processing on projects that aim for accredited environmental performance (Flemming, 2004), or allowing greater building flexibility (eg. on site building density and floor area ratios) for buildings that incorporate environmental designs (Lee & Yik, 2004) have also proved effective at reducing environmental building impacts but to a varying extent.

Incorporating building use costs into the initial sale cost of a building is one approach to providing owners with an incentive to incorporate environmental characteristics into building design; dealing with the issue of split incentives. Energy performance contracting (Yik & Lee, 2004) offers one method where by costs and benefits of reducing building energy demand can be shared between a contractor and a building occupier. A broader incentive approach can be taken with performance based contracting where maximum impact criteria can be set with incentives given for further improvements (Planet One Sustainability Strategies & Centre for Design RMIT, 2003).

The Seattle Built Green incentive scheme is interesting for targeting the design and building process as much as the standard of the end result. It provides contractors or building owners with a monetary award for building a minimum number of family units which meet set environmental criteria (City of Seattle, 2004). The incentive scheme is targeted at projects in the pre-design phase and requires successful applicants to form and conduct a working group where all stakeholders in the project discuss how they can influence the environmental impact of the buildings and meet all criteria. Most of the cash incentive is given upon meeting minimum building criteria in the building plans but must be repaid if the end result does not meet required levels. In this way, it acts as an incentive for increasing knowledge and experience of green building (City of Seattle, 2004).

Public Procurement also has a role to play in opening up new markets for alternative buildings. In Australia, where general housing industry inertia is contributed to by unresponsive and poorly standardised legislation that shapes 'customers' buying decisions in favour of the status quo", risk-aversion is understandably high. In this environment, industry players feel that at least in the early stages "...there is a clear role for Governments to show leadership by sharing risk, in order to show the way" (Institution of Engineers Australia, 2001).

4.7.3 Educational Methods

Pfeiffer, (1999) argues that there are two main reasons why builders don't embrace green building: not wanting to throw away old knowledge and re-learn and the perception of higher costs. This attitude exemplifies the lack of understanding and awareness that the application of green building does not necessarily mean knowing new 'tricks' but merely applying the fundamentals of building and architecture in a more integrated fashion (Ngowi, 2001). Education tools to break this perception are therefore critical (Powell & Craighill, 2001).

While conventional tools such as workshops and conferences can play an important role in spreading knowledge (Anon., 1999), this form of education is not always successful on its own. For example, despite government driven campaigns highlighting the importance of water and its high cost, consumers in Abu Dharbi have one of the highest rates of water use in the world (Abu Qdais & Al Nassay, 2001).

It appears that industry groups themselves play a major role in spreading knowledge. The LEED environmental building labelling scheme is one industry led tool which has proven very successful, acting to both educate the market and facilitate greater interest in the economic incentives of building green (Building Design & Construction, 2003). It has also acted as a platform from which governments have been able to base other incentive mechanisms on. In the experience of Dobrovolny (Pers. com.), Sustainable Building Coordinator for the Seattle City Light who has worked with two 'Green' building incentive schemes; "*Having a benchmarking tool has been essential for both*". Incentive mechanisms work best when they are coupled with clear performance targets. By merely setting targets, 'Green' building labelling schemes [eg. BREAM (UK), LEED (US), HK-BREAM (Hong Kong)] are likely to facilitate greater awareness within the building community through simply highlighting the various benefits that can be gained from an alternative approach to building. As Rattenbury in Weisenberger, (2004) describes, "*Sometimes the incentive is to achieve a LEED rating level for its own sake. Other times, design teams and even municipalities use LEED to minimize the environmental impact of a proposed development and achieve a building permit. And sometimes economic incentives alone drive the effort*".

5 Material and Technical Characteristics of Aqaba's Built Environment

"A doctor can bury his mistakes, but an architect can only advise his clients to plant vines."

– Architect, Frank Lloyd Wright.

This chapter, together with Chapter 6, addresses the first research question:

Where and how does 'Beige' Building out perform the status quo of Aqaba residential construction?

Here, results from field observations and interviews conducted in Jordan are outlined to present a picture of the current state of residential building in Aqaba. Focus is placed on cost, aesthetic and physical characteristics.

5.1 Traditional Building Styles of Aqaba

Traditional buildings are comprised of various combinations of mud, mud and straw and stone. Archaeological excavations show Byzantine era construction styles involved creation of very thick mud and stone walls, sometimes over 1m in width. In both Byzantine and Roman era buildings, local stone was often used as a foundation upon which earthen walls were built. The remains of old walls show that mud brick was common (Fig. 5-2) and this practice was still present in Aqaba well into the 19th century (Fig. 5-1). A few buildings in use today are also of mud brick construction (Hanna, 2005). Traditional roofing was a combination of mud and straw with wooden beams and palm fronds providing structural support (Tukan, Pers. com).



Figure 5-2 Byzantine era use of mud brick walls in Aqaba



Figure 5-1 Aqaba mud bricks in construction [Image courtesy of Khammash]

5.2 The Current Aqaba Built Environment

The residential built environment in Aqaba consisted of 20 366 housing units in 2004, representing a 17% increase since 1994 (Hanna, 2005). In the last few years the built environment of Aqaba, like the most of Jordan has undergone a period of far greater growth. Between 2001 and 2004 land licenses allocated by ASEZA more than doubled from around 123.5×10^3 m² to 295×10^3 m². The number of building permits granted showed similar growth, up from 256 in 2000 to 908 in 2004 (Anon., 2005a).

Residential buildings are dominated by apartments (73% of housing units), and Dars* (23%) (Hanna, 2005). Occupancy characteristics of the built environment have changed. Vacant

* A Dar is a low income, one or two roomed building.

housing has increased from 10 to 17% since 1994 and is now 26% in some districts. While private household occupancy is the predominant type, rental apartments which make up between 45% and 65% of all housing units (depending on the district) are increasing as a proportion of total housing (Hanna, 2005; Al-Nidal; Abu-Akhmed, Pers. com.).

5.2.1 Greenscape

Public green spaces are generally designed using low water use hedges and ornamentals as boundary plants. Palms are the main canopy vegetation and lawn or paving is used for the larger areas of un-built land. Prominent spaces such as along arterial roads and key roundabouts are also planted with a combination of palms, ornamentals and sometimes



Figure 5-3 Prominent green spaces

lawn (eg. see Fig. 5-3).

Due to the low number of green areas ASEZA envisages the greening of Aqaba occurring mainly through private efforts to green around homes (CSBE, 2001; Al-Thaib, Pers. com.). As stated in the Design Guidelines, property setbacks are aimed to encourage land owners to vegetate and provide 'semi-public private spaces'. In theory, shallow setbacks to streets will reduce the construction of boundary walls and encourage exposure of building facades while wider setbacks will facilitate land owners to vegetate plots (CSBE, 2001). In practice, very few setbacks are vegetated and are generally paved or left bare (Al-Srouri, Pers. com; Pers. obs). Shade trees within setbacks are only common in the older, more established districts (Fig. 5-4).



Figure 5-4 Shading provided by vegetating setbacks

5.2.2 Building Orientation

Building orientation is dictated by road and zone planning (Aboyeshe, K.; Al-Thaib, Pers. com.; Pers. obs). With few exceptions, buildings face and open onto streets and main roads rather than internally or away from the street (Pers. obs.) (Fig. 5-5).



Figure 5-5 Glazing influenced by minor street orientation All windows face onto streets

Except where street orientation dictates southerly oriented buildings, most houses seem to prefer east and west orientation. Likewise, it is rare to see windows missing on the east or west sides and more common to find them missing on the north and south (Pers. obs) (Fig. 5-6).

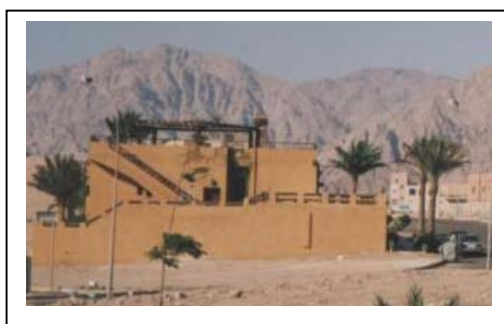


Figure 5-6 Example of a typically unglazed south facing wall

5.2.3 Design

Residential buildings are typically of uninspiring uniform block shapes (Pers. Obs) with little façade variation (Al-Srouri, Pers. com.). Styles are reminiscent of many tourist areas in southern Spain and have no apparent culturally influenced aesthetic (Pers. obs) (Fig. 5-7). The composite block designs of varying elevation preferred by ASEZA (see for eg. Fig. 5-8) are very rare.

Family owned residential buildings generally follow a typical life cycle in Aqaba. Land is bought and a single storey house is built, often after many years. Over time, with family additions or increasing wealth, houses will be expanded upwards and gain a second and after time, a third floor. For this reason, buildings have been constructed with expansion in mind; maximum allowable building footprints are used and roofs are constructed to enable latter conversion to a floor.

5.2.4 Materials

Concrete and stone dominates the built environment in Aqaba. With few exceptions, commercial buildings and multi-storey apartment blocks are constructed of a re-enforced heavy weight concrete superstructure and roofing with concrete block walls (Ravn, Pers. com.). Low-rise residential buildings are of hollow concrete block construction. (Al-Smadi, A.; Saboba, Pers. com.).

Wall styles of residential buildings (with very few exceptions) vary around three types. In the poorest areas, a single 10cm or 20cm hollow concrete block (HB) layer with plaster is used. (Fig. 5-9).

In the more wealthy districts, walls are constructed of a sandwich of poured concrete between internally plastered concrete blocks and an external structural layer of stone. Wall width is approximately 25 to 45cm. Expensive villas and older buildings will have over 10cm of stone (generally limestone), 10cm or 20cm HB and 5 to 10cm concrete (Saboba, Fahmawi, Abu Afifeh, al-Smadi, Pers com.). According to Fahmawi (Pers. com.) a recent trend (and one that reduces costs) is to increase the width of concrete and hollow blocks in replace of using stone for structural



Figure 5-7 Typical views of Aqaba residential built environment showing common apartment design styles

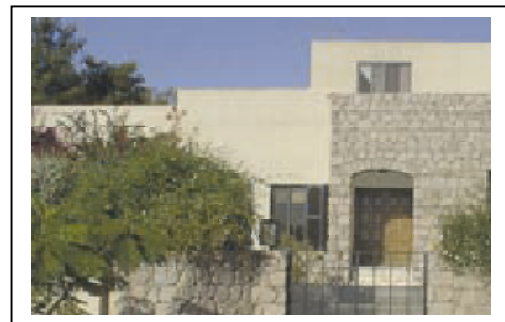


Figure 5-8 Example of ASEZA's preferred building design. Source: (CSBE, 2001)



Figure 5-9 One of the most basic construction styles in Aqaba



Figure 5-10 The standard high-end construction style using Ma'an limestone

support. (Fig. 5-10). At greater expense is the incorporation of a cavity between two HB layers. Cavity walls however are generally very rare throughout all of Jordan (Visser, Pers. com.) and

are more common in commercial buildings (Fahmawi, Pers. com.). The most popular style used for the external facades of buildings is the use of white and off-white Ma'an limestone. Its use is partially restricted by ASEZA and growing numbers of buildings are applied with earth coloured renders or limestone (Al-Smadi, A. Pers. com.; Abu Afifeh, Pers. com.; Pers Obs).



Figure 5-11 The only residential roofing construction style used in Aqaba today

Roofing in residential buildings is all rib-block construction (Haddad, Pers. com.; Saboba, Pers. com.; Pers. Obs.) (Fig 5-11). This consists of 20cm hollow blocks slotted between concrete beams and overlain by a layer of concrete. In some commercial buildings, slab concrete is used.

Single glazing is by far the norm with only elite residential and commercial buildings using double glazing windows (Abu Afifeh, Pers. com.; Fahmawi, Pers. com.).

Insulation is very rare in the Aqaba built environment. General estimates by contractors and architects operating in Aqaba put the number of residential buildings using some form of polystyrene at around 5% (Saboba, Pers. com.) with some estimates as low as 1% (Ravn; Abu Afifeh, Pers. com.). Expanded polystyrene is the most common insulating material used in Aqaba although 'rockwool' is also present (Ravn; Saboba, Pers. com.). Aerated (or light weight) concrete which has better insulation properties compared to traditional



Figure 5-12 Rubble filled cavity walls, planned KFC restaurant, Aqaba

aggregate concrete is often sprayed over slab-roofing on commercial buildings (Ravn, Pers. com.). In cases where cavity walls were intended to fit insulation it is typical for these to be filled with rubble and thus eliminating any cavity insulation to the building envelope (Awad, Pers. com.; Pers. Obs.). (Fig. 5-12).

Most materials used for construction in Aqaba are sourced from outside the zone. While no figures are collected in Aqaba, Najar of National Construction Company (Pers. com) considers that excluding cement aggregates, more than 90% of all building materials used in Aqaba come from outside the ASEZ. Aside from aggregate, the most common local material used is unshaped granite from the local hills. This is sometimes used on the lower levels of some building facades, perimeter walls and occasionally in the buildings themselves (see Fig. 5-13). Some small and medium scale manufacturing companies exist which supply



Figure 5-13 Local granite used in Aqaba. Source: (CSBE, 2001)

the local market with a limited array of products such as framed windows and cut stone, the majority must be imported however. External sourcing of materials and products makes costs higher, despite the duty free status of the zone. Wood for example costs around € 1170/m³ (Haddad, Pers. com).

5.2.5 Resource Use

The primary energy source in Aqaba is from an oil powered electricity plant. Residential electricity demand constitutes the largest consuming sector and is steady growing. Recorded domestic consumption ranges in the order of 24% of total consumption (Division, 2004), in line with the national figure of 23.1% (Jaber et al., 2003). Al-Hakim (Pers. com.) estimates that 45% of total capacity in winter and between 70 and 80 percent in summer is directed the way of the built environment (residential, hotel and commercial sectors). The high seasonal difference is solely attributed to increased air conditioning use (Al-Hakim, Pers. com.).

Estimates of residential water use in Aqaba put it at around 25% of demand with small and medium enterprises (including hotels) using about 30% (Al-Zoubi, Pers. com.). Residential water demand is increasing quite rapidly. Al-Zoubi (Pers. com.) estimates that this growth lies somewhere below 10% per annum. Individual consumption is estimated at around 44m³/year (Saleh, Pers. com.)¹. This is similar to Syria (41 m³/year), slightly lower than the national average of (54 m³/year) but substantially lower than Saudi Arabia (94 m³/year) and Lebanon (124 m³/year) (Food and Agriculture Organisation, 1997) In (Khosh-Chashm, 2000). The figure for Aqaba may be higher, given that estimates of between 26% and 36% of water provided to Aqaba is unaccounted for (Dardasawi, Pers. com.; Saleh, Pers. com.) and water stealing is common in the poorer areas on Aqaba (Shamuh, Pers. com.).

5.2.6 Cost of the built environment

Buildings vary very little in their skeletal composition and design (Aboyeshe, K; Ravn, Pers. com; Pers. Obs). Thus a reasonably accurate assessment of building skeleton costs (at the time of this study) can be made. According to Abu-Afifeh (Pers. com.), building skeleton (excluding foundations) of low-cost apartment buildings range in the order of 63 - 75 €/m². Finished styles however can vary from an additional 50% to 150% on building costs per m² (Abu Afifeh; Aboyeshe, K. Pers. com) making the costs of turn key constructions vary highly. Labour costs generally sit between 20 to 30% of total construction costs (Abu-Bakhr, Pers. com.). Material costs are around 75% of total costs (Abu-Afifeh, Pers. com).

Building purchasing costs are considerably higher. For turn-key apartments, Al-Jamal (Pers. com.) considered costs typical at around 460 €/m² for first floor and around 400 €/m² for subsequent floors. Villa's are more expensive and typically range around €149 500 for a floor area of 150m² (>920 €/m²).

Domestic cooling constitutes the largest on-going expense for residential building occupiers in Aqaba excluding rent (Shamuh, Pers. com). The money spent on air conditioning depends largely on the income of the family. Poorer families utilise evaporative coolers which are cheaper than the split-unit air-to-air chillers used by more wealthy families and commercial enterprises (Vox pop 1 – 7; Shamuh; Khrisat, Pers. com.).

¹ NB: While consumption estimates used here are given by employees within the Aqaba Water Company (AWC), at the time of study, their water data system, recording consumption, distribution and billing data for the whole of the ASEZ was giving very misleading results and needed complete overhauling. This fault was not known by AWC until this data was requested for the report and its validity questioned.

In the summer months, air conditioners are commonly used 24hours a day and demand between 20 and 35% of a family's income to electricity. Buildings require cooling for 9 months of the year from March to November (Shariah, Tashtoush, & Rousan, 1997). Members of the Aqaba public stated that summer air conditioning costs were double that of costs in other periods in the year (Vox pop¹ 1 – 7, Pers. com). Professionals (eg. Ravn; Aboyeshe, K.; Khrisat; Aboyeshe, M²., Pers. com.), whose private cooling costs ranged from 90 to 230 €/month, estimated that typical summer air conditioning cost for Aqaba families is around 80 to 150 €/ month. Interviews with people in the low income areas indicated costs in the order of 35 €/ month or around 25% of family income (Vox pop. 1 – 7, Pers. com.).

In support of (Shariah et al., 1997) assessment, all interviewees noted that heating was only needed in a few months a year and according to many interviewees is really only used for a few weeks.

¹ Street-curb discussions with a group of 12 residents of the Old Shalallah district were made (about 15 more were listening)

5.3 Thermal Performance and Cost

Aqaba wall and roofing composition offer very poor thermal insulation. Referring to Table 5-2; wall styles 1 - 5 and roof style 14 are the most common variations in construction styles found in residential Aqaba buildings. While they are the most common, these do not meet the Jordanian national building code whole wall and roof 'U-value' minimums of 1.8 and 1.0 [W/(m².K)] respectively. Wall styles 6 – 8 show characteristics of rarely used constructions in Aqaba. Wall styles 9 – 11 and roof style 2 offer potential but yet unused wall styles with greater thermal characteristics within the same cost range as standard construction styles. It is important to note that the values give here are for un-broken building envelopes (not whole-wall U-values). Adding windows and doors, small air gaps and small construction faults will result in increasing the U-values listed (reflecting a reduction in their insulating qualities). Wall style 12 is unused but closer to traditional styles. It provides less thermal resistance but has good thermal mass properties.

Table 5-1 Cost and thermal properties of wall and roofing construction styles found used in Aqaba

Type	Construction type	Cost ¹ (€/m ²)	U-Value W/(m ² .K)
Wall 1	2cm Pl : 1x10cm HB	8	5.529
Wall 2	2cm Pl : 1x20cm HB	9.5	2.564
Wall 3	2cm Pl : 1x20cm HB : 10cm C : 5cm Lst	28.5	2.010
Wall 4	2cm Pl : 2 x10cm HB : 5cm Air : 10cm C + 5cm Lst	32	1.855
Wall 5	2cm Pl : 10cm HB : 7cm C : 10cm Lst	48	3.282
Wall 6	2cm Pl : 1 x20cm HB : 10 cm C : 20cm Gr	21	1.739
Wall 7	2cm Pl : 1 x20cm HB : 3cm P : 10cm C : 5cm Lst	32	0.752
Wall 8	2cm Pl : 2 x10cm HB : 2cm Air : 3cm P : 10cm C : 5cm Lst	38	0.528
Wall 9	2cm Pl : 1 x20cm HB : 5cm P : 10cm C : 20cm Gr	51	0.711
Wall 10	2cm Pl : 2 x10cm HB : 5cm P : 7m C + 3cm Lst	51	0.562
Wall 11	40cm StwB : 16mm C Render : steel reinforcing mesh	19	0.242
Wall 12	30cm Rammed earth	10	2.500
Roof 1	2cm Pl + 1x20cm HB + 5cm C	10	1.776
Roof 2	2cm Pl + 1x20cm HB + 5cm P + 5cm LWC	18	0.457

NB: Where, Pl = Plaster; HB = Hollow block; C = Solid aggregate concrete; P = Expanded Polystyrene; Gr = Uncut granite stone; Air = Unventilated air gap; Lst = Limestone²; StwB = 3 string straw bale. LWC = aerated concrete

¹ See Appendix 2 for details on construction cost quotes for these figures

² NB: Costs of 'Limestone' are based on a 15 JD/m² selling price for Travertine stone (one of the most popular new stones being used in replace of the restricted white Ma'an stone).

6 Applicable 'Beige' Building Techniques for Aqaba

This chapter presents alternative building options to the current state of residential construction detailed in Chapter 5 and details:

Where and how 'Beige' Building practices out-perform the status quo.

The following sections describe basic design elements and building features which, if applied whole scale, will lower the resource and energy demands of the Aqaba built environment.

In the geography of Aqaba a number of principles can be followed in the design and construction of residential homes that will contribute to thermal comfort, lifetime-use cost reductions and a closer symmetry between the built environment and its natural surrounds. These are a) minimising heat gain, b) improving heat rejection and d) using local materials.

6.1 Orienting to Local Conditions

Simple steps for improving building characteristics should take into account orientation of sun and wind.

- Minimum wall surfaces facing east and west, minimal or no glazing to the east and west and priority glazing to the south.
- Multiple glazing on all windows, especially to the South, East and West
- Window to wall ratios should be as low as possible and well below 0.18

According to Fahmawi, the cost of designing for north-south orientation would vary considerably across Aqaba depending on plot orientation. Since plot orientations are effectively dictated by street orientation, building along for east-west streets would demand no additional cost (Fahmawi, Pers. com.). Along north-south oriented roads however, the ability to provide southward glazing is extremely constrained and therefore expensive. Adjacent buildings on north-south streets will restrict solar gain and views to the south and dictate that primary solar gain is from the east and west.

6.2 Using local materials for envelope construction

The following characteristics need to be considered when choosing materials for construction.

Diurnal temperature variations in Aqaba are less than 14°C which is not large enough to warrant widespread adoption of high thermal mass as a primary tool for minimising thermal gain. Thermal mass will be useful in Aqaba where buildings have only day-time occupancy or they have very good night-time ventilation. In situations where transferred heat cannot escape, use of high thermal mass walls will only retard the rejection of heat.

Local earth and stone materials are applicable for rammed and mud-brick construction to provide good thermal mass. However, soil with 30 to 40% clay is critical for rammed earth and Aqaba soils are generally very low in clay content; ranging from <1 to 2.3% (Al-Farajat, 2001). Suitable clay content was found in soil around the Port 1 area (Pers. obs.) and anecdotal evidence suggests suitable soils exist around the airport (Khammash, Pers. com)

and the Aqaba Phosphate plant (Najar, Pers. com). Investigation needs to be made into the extent of local clay resources and the distance to harvestable clay. Cement stabilised earth is one option that can be used when clay content is low; as is gypsum-stabilised earth. Historical remnants of earth walls in Aqaba suggest wall thickness of 40 to 60cm and more were required to achieve needed delay in heat transfer.

6.3 Enhancing Thermal Resistance

Use of polystyrene and ‘rockwool’ in cavity walls offer dramatically improved thermal resistance over the conventional building styles. They are not environmentally benign material but are cheap and effective. Straw bales with thick renders have very high insulating properties, they are also lightweight, easy to build and have low material costs.

Aqaba roofs must have higher thermal resistance than walls. Polystyrene rather than rockwool is more applicable since it will not compact substantially under pressure. It is also widely available. Few alternatives exist. Straw in the roof space and aerated (or light weight) concrete above the roof have been used in Jordan and will provide better performance than the status quo but neither are ideal for use as a load bearing roof – eg for a second floor.

6.4 Shading

The following options are applicable to increase shading in Aqaba.

External shuttering is critical for preventing some solar gain and should be used flush to the building envelope. Wooden shutters, overhanging lintels, metal shutters, and bamboo blinds are all available locally.

Vegetation can reduce thermal gain through shading and can be facilitated by:

- growing creeping vines over trellised walls, (see appendix 6 for a suggested species),
- growing shade trees next to walls (See appendix 6)
- extending horizontal shading devices out from the roof level to shade walls and growing plants over them.

‘Auto-shading’ of buildings, by designing constructions back-to-back on facades that receive the greatest incident radiation (to the east and west) is also an option. (Fig. 6-1) shows two buildings with the same North East orientation. Due to the shading provided by the building on the right, the solar gain on the South East facades of both buildings will be dramatically different.



Figure 6-1 Two buildings with dramatically different incident radiation.

6.5 Heat Rejection and Natural Cooling

Rejecting heat is one of the easiest ways to reduce cooling loads and Aqaba has ideal wind conditions to drive heat rejection. The following ‘low-tech’ options are applicable to Aqaba.

Use of wind towers and north-south orientation to capture wind: Wind is predominantly northerly, and is almost a constant 3-5m/s (Aqaba Office of Meteorology, 2005). Facing building openings (doors and windows) north-south is a costless approach to cooling provided orientation is factored in at the design stage. A variation on this theme is the use of

low air inlets facing north with outlets high in the building to the south to maximise cross ventilation.

Domed roofing: domes could also be very effective in Aqaba As a way of catching and stratifying rising hot air and providing a focused outlet,. The lack of rain and prevailing winds make the use of domes with openings at the apex ideal.

6.6 Minimising water wastage

Greywater recycling is applied on a very limited scale in Jordan but it represents a large unused resource for domestic garden irrigation purposes. Local plumbers put the cost of source separation of grey and blackwater and diverting greywater to sub-surface irrigation at around €115. This would involve use 5cm polyvinyl piping to run water through a physical (sand and gravel) filter to an outdoor 0.5m³ storage tank and then to a garden (Saboba; Awad, Pers. com.). Even simpler, pipe-to-garden systems have been estimated at around €23 while complex (and unnecessary) secondary filtering systems have also been constructed in Jordan for €440 (Centre for the Study of the Built Environment, 2005).

Add on household water-fixtures for reducing water consumption are available at cost-price from the Aqaba water utility.

6.7 Application of Alternative Technologies in Aqaba

Results of basic trials and interviews with local alternative technology practitioners suggest that while many alternative technologies can be applied domestically, they are very expensive and not applicable for the majority of Aqabians. Others appear promising.

Solar cooling, a technique using a solar heat collector used to power a separate evacuative-tube chilling device is commercially available in Jordan. A 4 ton system is commercially available at around €5 650 to €6 770, installed. This can pay for itself in around 4 to 5 years when used to heat and cool a large villa and heat a swimming pool (Maaitah, Pers. com). Given the cost of a conventional 4 t air to air chilling system sits at around €1 250 + installation (Irtash, Pers. com.), a 4t solar cooling system if just used only cooling will have a payback of around 6 to 8 years (Maaitah, Pers. com). Solar dehumidification units are available and far less costly than cooling units (€300). These can increase effectiveness of conventional cooling or even wind assisted evaporative cooling (Maaitah, Pers. com).

Wind power generation is not widely applicable to homes in Aqaba. At 12m elevation, average local wind speeds range in the order of 3 to 5 m/s over a year (Aqaba Office of Meteorology, 2005). At this height, speeds offer only a marginal opportunity for using wind as a source of power. This wind speed is around the minimum operating speed for generating devices (Iowa Energy Center, 2005). Furthermore, equipment, materials and expertise are prohibitively expensive for individual applications in an urban context at present in Jordan (Samman, Pers. com). Al-Taher also believes wind is simply not feasible in Jordan at the current rates of prices and demand. Wind speeds at 20 and 40m heights are considerably higher (Monnich & Strack, 2001) and may offer some potential for wind power. However, generators of this size are clearly not applicable at the domestic level, are beyond the scope of this thesis and should be looked at in the context of wind farming.

Solar resources in Aqaba are plentiful with over 340 clear days (Aqaba Office of Meteorology, 2005). However Photovoltaic electricity generation is very expensive in Jordan and cost of technologies is prohibitive. A residential 80W system for example costs around

€320 installed (Samman, Pers. com). There is simply no economic incentive for grid connected domestic applications and this is believed to be the main reason why residential demand does not exist (Samman; Maaitah, Pers. com.). All suppliers and practitioners of this technology interviewed also said that their only applications of PV were in government projects (Al-Taher; Maaitah; Samman; Haddr, Pers. com).

Geothermal heating and cooling systems are currently unused Jordan. A feasibility test in Amman was not successful due to the local dry soil conditions and poor efficiency of the heat pump used (Taher. Pers. com). In Aqaba, particularly adjacent to the coast, application of geothermal heat exchange for cooling is likely to be more successful. Ground waters within the first few kilometres of the coast are shallow – in the range of 0 to 30 meters grading away from the coast (Al-Farajat, 2001). In this area ground water temperatures range in the order of 23 to 25 degrees (Al-Farajat, 2001), offering a temperature difference from ambient summer conditions of around 10 to 20 degrees. Calculations run with RETScreen software (Minister of Natural Resources Canada, 2005) indicated a greater than 25 year payback on the cost of installing a geothermal cooling system in the ‘Base-case’ conventional home. Very high first costs were attributed mainly to the estimates within the model which specified fixed drilling depths of around 100m. This is around the same depths typically drilled for geothermal heating systems in Sweden. If this is applicable to Aqaba conditions, domestic applications are not feasible since drilling costs range around 115€/m. Near the coast, deep drilling may not need since ground waters are very shallow. Furthermore, applications using gulf waters for heat exchange may be feasible and in coastal applications, and avoid drilling altogether.

Solar hot water heaters are common throughout Jordan. Al-Taher (Pers. com.) estimates that more than 25% of buildings use solar hot water heaters. In Aqaba a 3 panel, 150L system will cost around €430. An equivalent function electricity and gas heater will cost €57 and €130 respectively. In many Aqaba buildings, hot water heating is only used in winter since summer temperatures are so extreme, solar hot water heaters are turned off (Nemr, Pers. com.). This can be verified by my personal experience, where passive water tanks on the roof of buildings supplied hot water during the period June and July in Aqaba (Pers. obs.).

6.8 Impact of Material Choice on Cooling Costs

Small improvements to the building envelope from conventional styles can reduce cooling costs. These improvements can pay themselves back in time.

Table 6-1 Cost and cooling requirements for three building variations in an Aqaba¹

Scenario	Cost of skeleton construction (€)	Cost of A/C units required to cool (€)	First Cost (€)	Annual Cooling Load (kWh)	Annual Cooling costs (€)
Base case	8 600	950	11 545	60 085	2 042
Minor improvement case	10 150	950	12 688	52 382	1 781
Advanced case	10 900	475	12 677	30 228	876

¹ See Appendices 2 & 3 for details of these three cases and Table 3.1; Chapter 3.3.3, for methods of calculating the following results.

Table 6-1 shows that the ‘Minor-improvement’ and ‘Advanced’ building scenarios are able to provide a 17% and 56% reduction respectively in annual cooling loads and associated air conditioning costs compared to the conventional ‘Base’ case building style. This is achieved at a respective first cost building premium of 15% (€7.3/m²) and 21% (€10.8/m²) compared to the ‘Base’ case. If air conditioning unit costs are factored into the first-cost of the buildings, the cost premiums of the minor improvement and advanced cases are much less: 9% (€5.3/m²) and 9% (€5.2/m²) respectively. Annual cooling costs for the Base, Minor-improvement and Advanced cases are €9.6, €8.1, €4.1 per m² respectively. These figures show that cooling costs can be more than halved by changing building orientation and material composition.

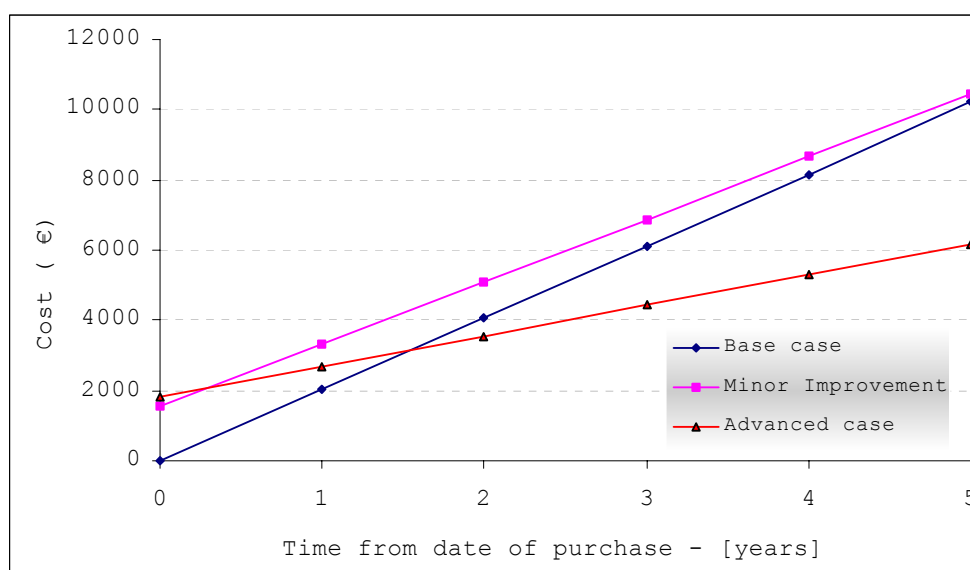


Figure 6-2 Payback on initial investment into improved housing performance resulting from reduced cooling costs (initial costs include air-conditioning unit requirements)

Figure 6-2 indicates that the extra first-cost outlaid for the Advanced case (compared to the Base case) is returned in less than 2 years by savings in air conditioning costs. The corresponding first-cost premium of the Minor-improvement case over the Base case takes more than 5 years of cooling cost¹ savings to be returned.

¹ In calculating cooling costs, sensitivity analysis involving variation in energy costs did not play a major role in influencing pay-back time (due to the short period) and were not included for this reason.

7 Issues Influencing the Built Environment

This chapter highlights contextual forces affecting decision making in Aqaba's built environment. It addresses the second research question:

What forces influence (promote & retard) persistence of the current built environment form?

These forces are categorised as either normative, capacity related, utilitarian or regulatory in nature.

7.1 Normative Influences: Attitudes to change

7.1.1 Perceptions of the Aqaba Built Environment

Interviewees were very accepting of the built environment in its current form. People expressed very few negative comments, except regarding the costs and restrictions imposed by ASEZA building regulations. Without exception interviewees considered the cost of land and buildings too high for the majority of Aqabians to own property. The costs of water and electricity were also widely complained about. This was seen as a major cause of stress in Aqaba's (Jordanian) population which earns on average, at or just below €225/month (Hanna, 2005) and deals with average rental costs of almost half of this (Shamuh, Pers. com.).

7.1.2 Awareness of Natural Resource Issues

Environmental awareness is generally very low in Aqaba. As a community development officer noted: "*most people don't think the environment is part of their life*" (Shamuh, Pers. com.). Al-Zaubi, director of Aqaba's municipal water supply company (AWC) noted one respondent to a survey investigating awareness on water issues answered a question about the origin of Aqaba's water, writing that water came from the tap (Al-Zaubi, Pers. com.). The very poor survey response rate (less than 5%) also suggests a low level of public concern for water issues. Residents expressed little understanding of the consequences of living in a highly inefficient built environment. A concern over high energy and water prices and the impending prospects of higher costs was expressed by many interviewees but non-professionals living in Aqaba generally failed make the conceptual link between resource cost and resource scarcity. Non-professionals also failed to link building material and housing design with energy consumption in the home environment. The Aqabian poor were also apparently ignorant of how the incremental water and power tariff systems work (Shamuh, Pers. com); these are designed to encourage reduced water consumption.

Most building professionals displayed a low awareness of the link between the built environment and environmental issues. Despite some knowledge of energy principles in building, many seemed unable to make the conceptual cause-and-effect link between resource scarcity, high resource demand in the built environment and long-term consequences. With few exceptions, higher cost was the only factor perceived to be a consequence of resource limitations.

Conversely, senior members of ASEZA's planning and environmental divisions were very aware that resource demands of the built environment will have a major impact on the ASEZ as a whole. As Rousan (Pers. com.) expressed "*inefficiency of the built environment is a problem for everyone*". This awareness has not been matched by actions however. According to Shamuh, (Pers. com) for many in the ASEZ, ASEZA's focus on marine protection and industry

licence-to-operate has been at the expense of other critical environmental issues such as resource demand in the built environment.

Al-Zoubi (Pers. com.) from AWC is of the opinion that Aqaba's finite water capacity presents no problem to the ASEZ. Complemented by recycled municipal waste water, non-renewable supplies are expected to last until after 2010. The use of desalination for water is expected to begin between 2011 and 2018. Water prices are also expected to stay at the same rate or even a slightly lower than current production once large scale production is underway. However, desalination itself will not be AWC's responsibility and will be tendered to private investors. Both AWC and EDCO, the local electricity distributor, want to reduce domestic demand of water and electricity for cost reasons. Al-Zaubi (Pers. com.) states that AWC is almost running at a loss by providing water to households and EDCO is interested in reducing peak household consumption because this will extend the time when greater capacity is needed (Al-Hakim, Pers. com.).

People's use of water in Aqaba is symptomatic of severe arid-zone denial. Despite an obvious preference for arid-zone ornamental plants in parks and private gardens, potable water was regularly seen being used to clean public paths, asphalt in governmental car parks and the exterior of buildings (Pers. Obs). Leaks in the municipal irrigation system in public areas occurred almost daily during the research period and water was often seen running down prominent streets and overflowing from (public and private) over-watered green spaces (See figs' 7-1 & 7-2). Furthermore, water use on dry-tolerant plants such as palms was often excessive and/or poorly targeted.



Figure 7-1 (Left) This overflow from a garden watered less than 100m from ASEZA's main headquarters occurred every morning for the two months research was conducted in Aqaba. As did an irrigation pipe leak that occurred in the main boulevard; seen in Figure 7-2 (Right).

7.1.3 Perception of Responsibility

Little evidence was found of personal or institutional responsibility being taken for reducing resource consumption within the ASEZ built environment. AWC management saw reduction in residential water consumption as mainly the responsibility of the engineers association (Al-Zoubi, Pers. com.). Likewise the electricity distribution utility believed professional associations have the main responsibility for providing expertise on reducing residential electricity consumption (Al-Hakim, Pers. com.). Al-Bilal (Pers. com.), commissioner for environment and planning in ASEZA, also makes it clear that ASEZA expects the building industry to provide the leadership in resource efficiency and resource-use reduction. Khassm (Pers. com.), an engineer and regional manager of an outlet for commercial and residential cooling systems, sees the responsibility for improving practices in the local building industry as belonging to the local government.

Public perceptions of responsibility were mixed. Some residents expressed the opinion that ASEZA needs to provide stronger direction on reducing environmental impacts in built environment while others believed that ASEZA's strong approach to the built environment where "*everything is controlled in regulations*" mean that little personal responsibility was needed (Abu-Musa; Abu-Akhmed, Pers. com.). According to one community worker, a widespread and habitual disregard for rubbish collection points by the Aqaba public is symptomatic of both an abrogation of personal responsibility (Shamuh, Pers. com.) and ASEZA's heavy use of street cleaners to remove public waste which facilitates this responsibility avoidance.

To one building researcher (Al-Asir, Pers, com.), responsibility for reducing resource consumption in the built environment being taken up by the building industry could be client driven; once clients understand alternatives exist, understand the benefits and demand alternatives, only then will the industry respond. Building contractors also saw clients as the main drivers of any future shift to Beige-building (Saboba; Abu-Maitiq; Abu Afifeh, Pers. com.) rather than new laws. In Al-Asir's opinion, (Pers, com.) stated that even in response to a market demand for low-impact green buildings, the building industry would invariably: A) respond in a very amenable way to any new laws at a surface level but B) disregard aspects of building designs that incorporated concern for the environment as much as possible in order to cut costs.

7.1.4 Influences and Trends

Despite efforts of ASEZA to define and promote a local architectural aesthetic in Aqaba, the built environment is largely a product of external influences rather than in-situ evolution. Architect Khammash (Pers. com) links this phenomenon to the lack of any regional identity explaining that as yet "*no-one has written the genome for Aqaba*". Some desired characteristics such as modular block designs with varying elevations, coloured to complement the landscape are clearly defined on paper (CSBE, 2001) but there is little evidence to show that desired styles are being communicated let alone adopted in the local built environment (Al-Thaib, Pers. com.; Pers. obs.).

Building styles within Aqaba are heavily influenced by Amman. Not only is the Amman style of building (characterised by blocky designs, walled-in facades and use of white Ma'an stone) generally considered by Aqabans to be desirable (Al-Smadi, M.; Al-Jamal, Pers. com) many of the architects, developers and building and planning professionals within the ASEZ are themselves from Amman. Thus, there is a strong cultural imprint of the Amman style within Aqaba decision makers (Hadadden, Aboyeshe, Tukan, Nimer, Fsaifes, Pers. com.). Furthermore many of the new building owners in Aqaba are high-income professionals from Amman and they typically demand the building styles they are used to (Fsaifes; Al-Srouri, Pers. com.). In Garaybeh's opinion 'modern' housing styles in Jordan are ill suited. Commenting directly on the new-Amman style he argues people in Jordan "*think that to be civilised is to have a concrete house*" despite the fact that "*it doesn't reflect our history...and it doesn't reflect our heritage and it doesn't reflect our culture*" (Garaybeh, Pers. com). But as one contractor sums up the current trend "*now people are looking for the usual design, which is new [modern]*" (Al-Maitiq, Pers. com).

Other influential styles derive from Dubai and to a lesser extent Lebanon (Tukan; Al-Asad; Saboba, Pers. com.). Dubai is looked up to because of its prosperity, and well marketed glamour (Al-Asad; Tukan, Pers. com.). While Dubai represents a seductive shift away from local culture and traditions in the Middle East, this "*Disneyland, Las Vegas style is very contagious*" (Tukan, Pers. com.).

Abu-Afifeh (Pers. com) sees the momentum in the current direction of building styles as a major barrier to change. This momentum appears to be increasing in Aqaba since the local building sector is attracting many new ‘opportunistic’ contractors and developers (Zahra, Pers. com.) who are merely propagating the existing styles for profit “*people only want to make money*” (Maitiq, Pers. com). In the opinion of Khammash (Pers. com), “*no-one works with experimentation*” in Aqaba. A similar perception, often expressed by interviewees (for eg. Al-Asad; Garaybeh; Fahmawi, Pers. com.), is that a strong culture exists in the Jordanian building sector of not being innovative and staying with what everyone else in the industry are doing. Tukan (Pers. com.) takes a similar stance regarding Jordanian architects, stating that “*less than 5% of practicing architects are interested in innovative ideas*” as does Khammash (Pers. com.): “*architects don’t like concepts, only the look of the building*”.

Inertia to shift to a lower impact trajectory also exists on the demand side of the housing market. Lack of client imagination is a major problem (Tukan, Pers. com.). Khammash (Pers. com.) goes further, arguing that across the population generally “*people are scared of taking risks...they like to go the traditional, conventional way*”. This tendency to not question norms and stay with the ‘modern’ Amman style bodes ill for a region where people “*...are used to living in un-insulated buildings*” (Tukan, Pers. com.) and “*...are used to waking up and seeing air conditioners*” (Aboyeshe, K. Pers. com.). This habitual reliance on air conditioners is neither universal nor entrenched however as both Visser and Al-Asad (Pers. com.) observe that people’s use of air conditioning has grown rapidly in only the past few years.

Other characteristics of people’s behaviour influence the development, impact and style of the built environment. A poor culture of maintenance (Al-Asad; Emtairah, Pers. com.) for example can be seen in the low number and quality of private gardens and the fact that housing features requiring seasonal care (eg. external wooden shutters) are rarely used (Zurikat, Pers. com.). Abu-Akhmed (Pers. com.) makes a similar criticism that people are culturally unprepared for well designed homes that may require extra attention from their occupants. In his perception “*...even if he (an Aqabian) has [an] architectural house, he will crash and destroy it*”.

7.1.5 Perception of alternatives

Aqabians are cautious of new ideas in building but have shown some interest in alternative styles once they have been trialled. In his perception, Al-Asad describes most Jordanians as having a “*pattern oriented way of thinking*” within which new ideas are not adopted until something is seen as successful (al-Asad, Pers. com.). Abu-Afifeh (Pers. com) comments that this can be a problem for architects because people “*don’t know what they want*” in a building and therefore stick to the safety of the status quo.

Alternative materials such as earth are seen as quite radical (Al-Asir; Aboyeshe, K., Pers. com.) and Visser (Pers. com.) has noted a widespread poor perception of mud buildings. In an environment where people desire constructions to be built as quick as possible (Khrisat, Pers. com) people in Aqaba are disparaging of building with mud or rubble stone because it takes too long compared to construction with concrete blocks and is considered old fashioned (Abu-Maitiq; Fahmawi; Ravn; Vox pop 1, 2, 3, Pers. com). When they do opt for local stone, this is mainly as an external facing (Al-Smadi, M., Pers. com.) People in the poorest districts in Aqaba were also adamant that natural materials such as earth, mud and stone were outdated and undesirable. They want “*modern*” building styles and don’t consider building with anything other than concrete (Vox pop 1-6, Pers. com.).

There is also a strong perception that building for the environment requires lots of new materials, skills and technical add-ons that are very expensive and are not available in Jordan (Aboyeshe, M1.; Abu-Afifeh; Awad; Abu-Maitiq, Pers. com).

The lack of skills with alternative building styles has contributed to these styles having a poor image. When people saw a style of building that relied heavily on local rubble stone (the ‘SOS-Childrens’ Village’: designed by a well known Amman based architect), copies proliferated. However, these projects were typified by poor workmanship that did not involve the same level of skill and supervision; the poor and expensive results have actually acted as a disincentive to use local stone (Saboba; Ravn Pers. com). As other building professionals described, this was a result of traditional skills no longer being available “*the memory of this profession is lost now*” (Saboba; Aboyeshe; Abu-Bakhr, Pers, com.). Fsaifs and Haddaden (Pers. com.) also noted that contractors did not understand the integration of design aspects that resulted in the publicised higher energy efficiency of the original buildings and only copied some aesthetic elements. Thus people’s perception of energy efficiency in buildings is tainted by failed copies.

Khammash (Pers. com) also expressed the opinion that there is a “*social cost and psychological cost of experimentation*” because for a building owner it means going against the norm and having the potential of being cast as a radical; “*new materials have a social stigma*”. Al-Smadi, B. (Pers. com) describes his experience trying to promote waste water use saying it is “*very difficult in Jordan, not easy to convince people to re-use waste water*”. However, progress has been made in target towns like Irbid reducing the social aversion to greywater reuse with the use of using ‘in-home’ demonstration projects and education brochures (Al-Smadi, B., Pers. com).

7.1.6 Public relationships with ASEZA and local building regulations

Evidence describes a very distrustful and disrespectful relationship between the ASEZ community and the local government. There is also widespread lack of respect for regulations.

Many interviewees described a general belief in Aqaba that ASEZA deliberately takes a very isolated position from the community. Ravn and Fahmawi (Pers. com) both described it as impossible to get any response to questions from ASEZA officials on building issues and even more difficult to get access past security to talk to employees themselves. Other building contractors said they didn’t even bother trying to talk to ASEZA because they never felt they were listened to. Khrisat and Fahmawi (Pers. com) are of the opinion that there is little communication and common understanding between local industry and ASEZA. In the view of Khrisat (Pers. com.), ASEZA is very reluctant to give out basic information and considers this is a barrier to progress in itself. Al-Smadi, M. (Pers. com) had a similar opinion stating that ASEZA is widely seen as being very inflexible with regard to giving building project permission, maps and land data. Other interviewees (Vox pop. 1-4, Pers. com) were surprised at requests for their opinion on building and planning issues stating that no ASEZA workers came to their community to talk to them. Aboyeshe, K. (Pers. com.) also described a culture in ASEZA of avoiding the public when possible. This has been partly due to members of ASEZA being assaulted and threatened by members of the public over building and planning issues. Al-Husseini (Pers. com.) described one event when working in partnership with ASEZA employees that the latter were scared to enter some areas of Aqaba and would take non-governmental cars to avoid identification and confrontation.

Fahmawi argues that there is a serious problem in the relationship between the ASEZ public and ASEZA. In his opinion this is a result of many complex and partly historical factors:

ASEZA was set up with no public consultation, most of the old governmental decision makers have been replaced by people originating from outside the ASEZ and it has dramatically altered its approach to government multiple times over the last few years following changes of leadership. Furthermore ASEZA's perceived close link with both Israel and the United States adds to its unpopularity. A lack of trust and a lack of belief and participation in local governance is believed to stem from these factors (Fahmawi, Pers. com.).

Because people distrust the honesty of ASEZA and how it makes its decisions, they often feel that new regulations are created to benefit influential stakeholders (Najar, Pers. com.). A perception of hypocrisy is not helped by the public lack of understanding of regulations and reasons behind them. Common criticisms were that ASEZA is not uniform in its application of the building laws. "*Why can my brother build like this but not my friend*" (Abu Maitiq, Pers. com.). In Khrisat's view, if ASEZA desires energy efficient and low impact buildings it is being hypocritical because regulators and inspectors have only shown concern for building aesthetics. ASEZA "*stop the buildings if it has white colour but it [does] not stop the buildings for bad material*" (Khrisat, Pers. com.). Ravn (Pers. com.) also sees ASEZA as being hypocritical since it has very high expectations on industry to reduce pollution and places a lot of emphasis on environmental protection while controlling or part-owning the three most polluting industries in the ASEZ: the power station, the phosphate mine and the port. The vast amounts of phosphate dust emitted to the gulf and land surrounding the port during loading procedures (Pers. obs.) provides support to this perception.

ASEZA and the Aqaba community hold divergent values and attitudes on what is best for the local built environment. Contractors and architects express a typical attitude that the only problem with the Aqaba built environment is that building regulations are inflexible and ASEZA regulates it so much "*you don't have choice*" (eg. Abu-Maitiq; Fahmawi, Pers. com.). Owners and developers express a desire for an essentially a free-market, non-regulated approach (eg. Al-Smadi; Abu-Akhmed, Pers. com.). ASEZA on the other hand is trying to promote particular building characteristics and prevent the proliferation of others. Owners, architects and developers express the desire to use a type of stone that is popular in Amman and has a particular social prestige (Al-Haj, Pers. com.). ASEZA's attempts to minimise its usage are widely viewed with a lack of understanding, annoyance and antagonism (Abu-Afifeh; Al-Smadi; Maitiq, Pers. com.). This misunderstanding is also mirrored by public reaction to (among other things) regulation of parking issues, set back width, placement of commercial areas and building heights which raise the most community resistance (Aboyeshe, K.; Abu-Akhmed, Pers. com.).

People's perceptions of ASEZA are that they don't have a clear idea of what they are trying to achieve by building regulations and are over-regulating primarily to raising revenue from the enforcement of building regulations; "*Aseza [is] only interested in buildings, not people*" (Abu-Maitiq; Khrisat; Saboba; Abu-Akhmed, Pers. com.). The argument given is that building inspectors only check for building setbacks, stone colour, building heights and the ratio of floor area to plot size because these are the only features can be met with a fine if codes are broken. On the other hand ASEZA sees its economic style enforcement as providing flexibility for building owners. Further evidence of divergent views was the public perception that ASEZA's regulation was out-dated and not created in accordance with a long term-strategy "*its an old system which they don't want to modernise....they are still living in the middle of the last century*" (Abu-Akhmed, Pers. com. [translated]).

Working against regulations is a culture of non-compliance "*There is a general lack of regard for the codes and regulations*" among small operators and building owners (Tukan; Fahmawi;

Saboba; Awad, Pers. com.). This non-compliance is also combined with a widespread disrespect for the local authority. In the opinion of one real estate agent “*people are fooling ASEZA*” when it comes to compliance with regulations (Abu-Akhmed, Pers. com.). Al-Haj, a former planner with ASEZA went as far as to say that “*even big investors are not respecting the law*”, which appears to be true for at least one of the largest projects currently underway in Aqaba (Al-Haj; Aboyeshe, K. Pers. com.).

In the opinion of Fahmawi and Shamuh, (Pers. com.) the lack of respect goes two ways. ASEZA has generally taken a top-down approach to regulation and has made few efforts to engage the community in decision making. The lack of any formal community outreach mechanisms created by ASEZA (or local NGO’s) is a major problem according to Shamuh (Pers. com.). In her opinion, Aqaba’s primarily low income population is suffering because of ASEZA’s style of governance in which “*decisions are made from like a pilot*”. As she describes the situation “*people are stressed...people are afraid because they don’t know what is planned for the future*”. Although not referring specifically to Aqaba, Visser (Pers. com.) has the perception that many architects and policy designers in Jordan generally “*don’t have their feet in the mud*” limiting their ability to see what is practical and possible. This perception is also mirrored by people within ASEZA itself (Aboyeshe, K., Pers. com.).

7.2 Coercive Factors: Regulation of the Built environment

Regulation and enforcement of regulations within the built environment varies considerably in the ASEZ. National Jordanian building codes apply to all construction projects but in reality are ignored when it comes to building thermal requirements by public decision makers, local governmental site inspectors, the engineering association and the building industry (Aboyeshe; Fahmawi; Ibraiwesh, Pers. com.). Local building regulations vary in the clarity of their objectives and degree of specificity.

At the macro-scale, the layout of the Aqaba built environment follows the 2001 master plan (Gensler, 2002). This pre-determines the placement and orientation of building zones and main streets. Details within zones, such as design of minor access roads, built areas and public spaces are generally left up to major developers who must tender for contracts. Theoretically, the use of land in zones is influenced by the Design Guidelines (CSBE, 2001) which outline preferred characteristics such as building styles and use of green spaces in the built environment (depending on zoning categories). The Design Guidelines are not binding or directly referred to in either the building regulations or supporting codes.

The local building codes and by-laws, which provide specific (if limited) direction on building requirements, do not directly target any environmental impact or resource use issues. They focus mainly on aesthetic issues such as building colour, use of setbacks, plot building density and building heights. Some restrictions on the use of materials do apply but these are targeted to influence the aesthetic of the built environment.

Follow up and control mechanisms are weak in the Jordanian building sector. Authorities only check for basic diversions from the codes (set-backs, colour and shape) (Abu-Musa, Pers. com.). Al-Taher (Pers. com) is of the opinion that regulations wont work because “*the building code is never implemented*” and poorly checked. Inspectors “*just check floor area*” when inspecting homes. Fahmawi is of a similar opinion, “*there has been no checks of poor architecture and building*” but also believes that there is a low number of rules that exist because policy makers know they are not going to be obeyed (Fahmawi, Pers. com.).

7.2.1 Influence of Regulations on Environmental Building Performance

Environmental and natural resource use issues are poorly controlled by the ASEZ building regulations and codes. Some areas within the regulations (Aqaba Special Economic Zone Authority, 2004)¹ and codes do target or indirectly influence the resource demand and environmental impact of the built environment as do some elements of the local Design Guidelines (CSBE, 2001); these are highlighted below.

Utilising wind-towers and wind power generators: Regulations allow for special permission to be granted for ‘embellished parts’ to extend beyond the main building height. This includes the possibility for ‘cooling towers’ but no mention of wind generators is made.

Use of Set-backs and Plot density: Restrictions on plot densities and setback requirements in the ASEZ vary greatly depending on the zone, building height and placement to the street. Zero setbacks are only allowed between adjacent buildings with the same owner, following an agreement with adjacent plot owners or on street fronts.

Requirements for wide setbacks restrict design possibilities particularly on smaller land plots (Visser; Smadi B., Pers. com.). The ability to use a courtyard space is particularly limited because of set back requirements (Fsaifs; Haddaden, Pers. com.). Ravn (Pers. com.) states that unless buildings can be built to the property boundary, there is no room for courtyards and experimentation with building design. However, constructing buildings on property boundaries requires cooperation between architects, builders and adjacent land owners because it would result in buildings being constructed back-to-back. In Ravn’s eyes, it’s just not practical; *“I’d love to built it [a courtyard] but I don’t know my neighbours”* (Ravn, Pers. com.). Fahmawi (Pers. com) is also of the opinion that the limitation on plot building density limits the ability to for designers to create buildings for the environment *“...its difficult to make an environmental building in this area”*.

Building underground: ASEZA building regulations state that cellars and underground utility rooms are not considered a part of building floor area and are allowed as long as they are not used for living purposes.

Materials: ASEZA building regulations state that buildings must to be constructed out of ‘natural materials’ [Article 12-A] and suggestions are made as to what materials are preferred; mud included. However, the regulations and codes do not specifically restrict the use of any building materials except as they relate external building colour; which must reflect the natural colours of the region. Regulations also stipulate that materials should not be used that will have a negative environmental or health impact but there is no specific codes or by-laws referred to which stipulate either impermissible impacts or any penalty for causing negative impacts [Article 33. B, 3].

Shading: While the design guidelines recommend materials and styles to be used for shading windows, building regulations have no mentions of shading devices. However, they impact on some potential shading devices indirectly by requiring building over-hangings greater than 30cm to be included in building footprint calculations.

¹ NB: Assessment of ASEZA regulations was based on a draft translation.

Green-spaces: Regulations require 10% of plot area to be planted and provision is given for ASEZA to provide advice on the types of plants suitable [Article 24 D&E]. However building codes don't detail how this is to be enforced.

Thermal Insulation: Regulations state that insulation in walls and ceilings is required 'if possible' [Article 33. B, 1]. While the national codes require whole wall U-values less than 1.8 and ceiling U-values of less than 1.0 In the ASEZ, there are no code requirements for thermal values of walls, ceilings or windows.

Orientation: Design and orientation of buildings for reduction of solar gain and taking account of prevailing winds is required in the architectural stage of a buildings life [Article 33. B, 2]. There is no specification of what orientation is required or how winds should be utilised however.

Orientation of major roads and is prescribed in the Aqaba master plan (Gensler, 2002). Orientation of minor roads is obviously influenced by the placement of major roads but more-so by the development and construction companies who win tenders to design newly allocated zones. These designers are required to follow the master plan but according to Haddaden (Pers. com.) there is no direction given by ASEZA on street orientation. This is left up to the designers.

Enforcement and Compliance: The ASEZ regulations clearly state that "*any construction activities*" (draft translation) must adhere to the national as well as regional codes and regulations. This includes preventing changes to the building by the owner or developer without planning permission.

Monetary penalties for not meeting local code requirements on setbacks, floor ratio and building height etc. are applied incrementally depending on the degree area or height limits are exceeded. The greatest penalties are applied for exceeding setback requirements. ASEZA takes adherence to its local codes very seriously and is strict in its application.

A 10% licence fee charge is required to be paid as a deposit in lieu of completing the construction to plans [Article 45]. This does not include making sure that thermal insulation is installed.

7.3 Utilitarian Issues: Incentives to change

The perception of interviewees to change in the built environment and their ability to affect this change is strongly influenced by economic factors. As this chapter explores, the cost of essential materials is only one of many more complicated factors dictating how purchasing decisions are made; in particular macro-scale market trends and people's valuation of status.

7.3.1 Perception of Cost and Stakeholder Behaviour

People in Aqaba expect to pay more for buildings which differ from those churned out by the current market. Energy efficient design in buildings is widely perceived as requiring a high price premium by professionals with no experience of it (Abu-Maitiq; Khrisat; Al-Smadi A; Abuyeshe, K.; Aboyeshe, M¹., Pers. com). This is consistent with real experiences in the building industry. According to Khammash (Pers. com.), client or architectural requirements for non-conventional materials are often met with high costs from developers because the industry is only familiar with a small range of materials.

The high and increasing costs of land, labour and construction materials heavily restricts many people's ability to 'play' with building materials and styles (Visser; Smadi, B. Pers. com). Al-Smadi, A., (Pers. com) offered a similar assessment noting that "*Paying for design aspects or insulation is a luxury*". Or as one Amman based contractor noted, for most Jordanians' the ability to make critical decisions when constructing a building was highly restricted since "*their hands are tied with the price*" (Haddad, Pers. com).

Buyers put a very high priority on first-cost when making buying and building decisions, rarely making sacrifices for long-term benefit (Fsaifes; Haddaden; Al-Jamal, Pers. com). In the experience of architect Abu-Afifeh for example, clients don't like the idea of paying for insulation (Abu-Afifeh, Pers. com.). This is mirrored by experiences of building professionals, even when clients are explained the long term benefits of insulation (Fahmawi; Ravn, Pers. com.). In the opinion of one residential housing contractor, the majority of the Aqaba proportion is simply too poor to afford insulation (Al-Smadi, A., Pers. com). The perceived income of the clients determines whether his company asks them if they want insulation. Employees at the local Aqaba engineers association responsible for checking building plan compliance said that insulating buildings was too expensive to be feasible (Aboyeshe, M¹, Pers. com.). Neither Aboyeshe M¹. nor his colleagues could quote a price for insulation however.

In the opinion of most interviewees, the pressure placed on contractors by clients to reduce construction costs is very strong and adherence to the building codes is directly influenced by this pressure. Once plans are accepted by both the engineering association and local authorities they will often be modified (illegally) to reduce building costs (Fahmawi; Saboba ; Al-Smadi, A.; Al-Smadi, M.; Haddad, Pers. com). In the opinion of one material supplier: if allowed "*people would build with whatever they could to reduce the price [of a home]*" (Ravn, Pers. com.). The removal of insulation from building designs is most often driven by clients (Awad, Pers. com.).

Deliberate illegal modification to constructions is common. Three building professionals described in detail how this occurred on building sites when insulation is demanded by the client. Fahmawi (Pers. com) and Haddad (Pers. com) both described 'shoddy' insertion of insulation sheets so that vary large gaps (>1m²) are left between the polystyrene used. In another description, developers often go to the extent of filling all cavity spaces with rubble and then inserting a narrow sheet of insulation at the top to give the appearance of cavity insulation (Awad, Pers. com).

The pressure to reduce costs to the point of making illegal modifications to original plans is also driven from within the contracting firms (Haddad; Ibraiwesh, Pers. com.). According to Saboba (Pers. com.) another factor influencing adherence to the building codes and quality of workmanship is the downward pressure on professional wages (particularly engineers) by developers. In his estimate, wages have been pushed to a quarter of industry award wages in some projects (Saboba, Pers. com.).

Cost is also an issue in compliance checking. Al-Asir (Pers. com.) argues that checking for insulation, which is the responsibility of the engineers association, will only occur at the design stage because costs are minimised here. This appears to be echoed in practice. Aboyeshe, M¹. (Pers. com) states that the engineering association often checks for insulation in building plans. Onsite however, neither the supervising engineer, whose role it is to maintain compliance with regulations, nor the ASEZA building inspectors check for compliance with thermal insulation requirements (Abu-Afifeh; Aboyeshe, K., Pers. com.).

7.3.2 Changes to the Housing Market: The rise of real estate investment

The Aqaba built environment is undergoing rapid change. The number of buildings is increasing rapidly and Aqaba appears to be one of the few areas within the Middle East where speculators, both domestic and foreign are keen to invest. Given the lack of industry and diversity of areas to invest, this money is flowing into real estate. Recent changes to banking loan policies in 2003 which extended loan pay-back time have also contributed to greater investment in Aqaba real estate (Al-Deeb, Pers. com.). Meteoric growth in demand that has occurred in the last few years has pushed prices very high. Al-Najar (Pers. com), a popular real estate agent, describes some areas of land in Aqaba tripling in price in the first few months of 2005. The loans manger of the local branch of the Arabic Bank described a four to nine-fold increase in land prices over the last two years (Islamic Bank loans manager, Pers. com.). Planned major projects such as two constructed lagoons for tourism have contributed to this price rise.

In this environment, the demographic of home ownership is changing. Until very recently, around 95% of construction in Aqaba was owner-builder style residential homes (Abu-Afifeh, Pers. com.). Now the percentage of rented homes is increasing as is the proportion of apartments (Hanna, 2005) (Abu-Akhmed, Pers. com.; Al-Deeb, Pers. com.). This is seen as due to 1) rising land costs restricting low and middle income people buying and building and 2) the more wealthy land owners wanting to maximise return from their investment in land (Abu-Akhmed, Pers. com.).

Residential construction projects are also increasingly commissioned by speculative investors from outside Aqaba or wealthy local businessmen whose aim is to maximise returns from building projects (Al-Jamal; Al-Asir; Abu-Maitiq, Pers. com.). As Abu-Maitiq (Pers. com.) describes, investors are therefore building to sell or rent for the highest profit and don't care so much about quality or about the expenses of running the buildings. "*everyone does it*" (Abu-Maitiq, Pers. com.). This trend also appears to be seen in the 27% increase in apartments noted since 1994 (Hanna, 2005). As Fsaifs, (Pers. com.) notes, in this environment, there is no incentive for taking energy and water efficiency into account when building, since building owners can just "*sell the problem to another [person]*". According to one real estate agent who focuses mainly on the Aqaba rental market notes that a recent trend away from renting to owning houses is slowing in Aqaba and in the last 6 months demand for rental homes has increased (Abu-Akhmed, Pers. com.). Abu-Akhmed believes this is mainly due to the increase in low paid workers migrating to the area. Others state that the rising cost of land, building materials and labour costs have prevented all except the developers and the wealthy buying or building new houses (Al-Jamal, Islamic Bank loans manager, Pers. com.).

7.4 Capacity levels: Ability to Change

There is widespread lack of understanding from engineers, architects and professionals in the building industry about how environmental impacts can be reduced in the built environment. For many interviewees, their ability to conceptualise issues such as the need to reduction of energy and water consumption in buildings was strong but their level of technical understanding was very low. They all knew insulation played a major factor in energy consumption for example but many did not know how to calculate wall U-values. Furthermore, when discussing application of energy efficiency, interviewees typically focused on one influencing factor alone such as solar power or the use of thermal mass, rarely considering how multiple approaches could be applied together. Building professionals (including the Aqaba engineering association) have a technologically orientated perception of what is required to reduce building impacts. "*We need the equipment*" (Aboyeshe M., Pers. com)

was a typical statement made by building professionals. ‘Green building’ was seen as a foreign, ‘Western invention’ and one that would come with time once, Jordan emerged from its ‘developing country’ status.

There is a lack of knowledge of environmental or even efficiency issues in the building trade (Abu-Afifeh, Fahmawi, Pers. com). According to Aboyeshe M. (Pers. com), “*people are little aware of these [energy efficiency] issues*”. Likewise, many professionals within the ASEZ planning department did not have a strong understanding of DfE concepts in building. “*few inspectors really understand what a U-value is*” (Al-Haj, Pers. com.).

Even where awareness exists, few professionals have applied their knowledge “designers don’t take these facts [about ways to reduce energy use] into their calculations”. Furthermore, some fundamentals of building efficiency are widely misunderstood. For example, contractors, architects and engineers all suggested that building energy use in Aqaba could be reduced by minimising glazing on the southern aspect in exchange for more glazing on the north, east and west sides (for eg. Abu Afifeh; Al-Asad; Saboba; Zureikat, Pers. com.). Their understanding lies counter to fundamental energy conservation design principles applicable for Aqaba (Al-Asir, 2004; Shariah et al., 1997).

Engineers and architects did not show a strong understanding of how to measure or assess building energy demands and those that did had never applied these techniques in residential housing projects. This is considered typical for engineers and architects who rarely apply these fundamentals (Safi; Aboyeshe, Pers. com). Professionals who did show a clear understanding stated that retaining a practical level of knowledge was very difficult since they were rarely asked to apply it (Fahmawi; Khrisat; Irtash; Khalil, Pers. com.).

Lack of professionalism on the work site is also blamed for poor building energy performance. Workmanship is often of a low standard (Al-Asir, Pers. com) and contractors often don’t apply all that is written in the building plans (Al-Asir; Awad; Khalil; Aboyeshe, M¹; Aboyeshe, K., Pers. com). This is believed to be partly due to the lack of formal training (Ravn; Abu-Afifeh, Pers. com.) and the fact that most contractors are un-licensed (Aboyeshe, M; Aboyeshe, K.; Abu-Bakr, Pers. com). Poor professional training, the lack of experienced developers (Ravn, Pers. Com) and the high percentage of unskilled building workers attracted to the boom in construction (Haddad; Zahra, Pers. com.) also plays a role here. On the building site, poor training means the value of knowledge transferred between trades-people is low. “*most of the contractors are simply experienced builders with no formal trade education...they perpetuate the bad practices of [those] who taught them*” (Ravn, Pers. Com). Haddad takes a similar attitude stating that “*people are not really educated in construction matters*” (Haddad, Pers. com.).

Knowledge of alternative building styles such as using rammed earth, mud-brick or straw bale housing is low in Jordan (Khammash; Haddad, Pers. com.), mainly restricted to the oldest generations (Garaybeh, Pers. com.) and does not exist in Aqaba (Ibraiwesh; Khammash, Pers. com.). Even skill with using the local uncut stone is hard to find. This is reflected in the quality of much of the stonework (Fahmawi; Tukan; Khammash, Pers. com.; Pers. Obs.). In many instances where the stone is used, it is retained on a block wall with wire mesh and concrete is simply poured down the inside as filling. Thus, no effort is made to lay the stone and it is merely used as a finishing. As Ekremah (Pers.com) puts it “*there is no craftsmanship*”.

There is no formal medium for spreading awareness on environmental issues to the public on environmental issues (Fsaifs; Hadadden, Pers. com). There are no trade schools in Aqaba and capacity building in the construction industry has not been a priority for the local authority

(Nimer; Aboyeshe, K., Pers. com) or of the National Engineering Association (Al-Haj; Maaitah, Pers. com).

Within building projects there also appears a lack of communication and understanding between professionals. On most worksites, all the different sub-contractors are independent and so they “*don’t work as one group*” and don’t know about any project as a whole (Abu-Afifeh, Pers. com.). The Aqaba based building industry is small and a relatively new development since and has little experience and capacity for innovation (Khrisat, Pers. com.).

Of the various studies done or commissioned by ASEZA that have a focus on environmental aspects in the built environment, little effort has been made to publicise key findings. Few building professionals in Aqaba were aware of the ASEZA led competitions for designing low-cost energy efficient buildings and none had read any findings or new where to find information in them. Even within ASEZA no internal memos or reports have been published following any building competitions (Fsaifs; Hadadden, Pers. com.). Similarly, the Architectural guidelines put out by ASEZA which encourage the use of shading devices and planting are only available in English which limits their influence in the local industry. None of the interviewees outside ASEZA had read the guidelines. This lack of dissemination of internal or commissioned reports is seen as typical throughout ASEZA as is the lack of implementation of recommendations or follow up (Aboyeshe, K., Fsaifs; Al-Haj, Pers. com.). As Al-Haj notes there has been “*a lot of studies, [but] nothing implemented*” which mirrors Fsaifs assessment that there has been “*a low number of studies acted on*” by ASEZA. Poor information management is also evident from the lack of knowledge held by ASEZA employees regarding the existence of reports and collected data. This knowledge seems to be held by only a few individuals that had a strong history of continuity within ASEZA (Pers. Obs.).

Evidence suggests there is little integration and communication between trades-people in the ASEZ. Fahmawi perceives a deep lack of community in Aqaba responsible for trades-people not communicating and believes this is retarding improvement of the built environment and must change; “*we must share the local experiences*” (Fahmawi, Pers. com.). Despite wanting to reduce domestic use of electricity and water, and feeling that building professionals could play an important role to help, neither the water nor electricity providers had attempted to approach anyone in the local building industry (Al-Kaubi; Al-Hakim, Pers. com).

Part of the problem why buildings are so energy intensive according to Khrisat (pers. com.), is that people work separately and don’t think forward to the stage when air conditioners must be chosen and fitted. Owners don’t initiate the needed discussions with the designers and builders and air conditioning contractors. Most of the time, discussions with air conditioning professionals happen after buildings are built, so passive designs can’t be taken into account. In stressing the need for integration between workers and engineers on a project he suggests that timing is important; “*we need start from the beginning*” (Khrisat, Pers. com.). In a story that highlights the same need, Al-Taher described giving a presentation to developers for a resort district Tala Bay, south of Aqaba in the ASEZ. Focus was made on the benefits of insulation and developers were shown that a first-cost reduction could be gained by using insulation instead of the planned split air-to-air chillers. The developers still went with the air conditioning because they did not want to redesign the roofing required to include insulation (Al-Taher, Pers. com.). Too much work had already been done.

8 Discussion: Setting the tone for change

This chapter presents an analysis of results, stressing that problems in the Aqaba built environment are physical but persist because of mainly social and institutional phenomena. Drawing on research, it highlights where the forces identified as influencing the built environment are derived from and lays the arguments for:

What can be done to promote a 'positive' shift in the residential housing stock; toward 'Beige' building?

8.1 Aqaba under Strain

The built environment is a cause of stress for the ASEZ region. Evidence strongly suggests that the majority of the population are inhibited from purchasing land by its very high and increasing cost. Costs for buildings are also high, to the point where people feel they don't have the possibility to build. Building costs are also a factor reducing people's desire to purchase essential materials such as insulation. Aqabians on an average income are also not in the position to purchase new homes despite the increased ability to access loans. The cost of basic utilities also appears to be a major cause for social stress. Interviews suggest most people (including the professional population) are paying between 20 and 30% of their income on air conditioning in summer. When combined with the cost of water, utility costs present a major economic problem that appears to have strong negative social implications. Aqabians are certainly aware that utility costs are a major stress on the majority low-income earners in the ASEZ. The high peak loads caused by use of air conditioning in summer are a major problem that needs to be dealt with. It is only time when this high electricity use causes capacity shortages and problems with electricity supply.

Aqaba's built environment also has negative implications for the region's environment and natural resources. Water demand per-capita in Aqaba, though lower than many other Middle Eastern countries, clearly does not reflect the region's hyper arid conditions. Evidence suggests profligate use of sweet-water is common, while household recycling is extremely rare. Thus, unneeded demands are placed on Aqaba's limited water resources. The high level of air conditioning use is directly related to major increases in peak loads and combined with the energy requirements for the generation and transport of materials used in the building of most homes, represents excessive electricity consumption and generation of associated greenhouse gases.

8.2 Building Form and Function Directly Leads to Social Stress

The planning, design and material characteristics of the built environment are exacerbating social, economic and environmental stress. There is no evidence that building designs, including orientation, reflect the local geographic conditions. Insulation is virtually non-existent, proper orientation for the wind and sun does not exist and single glazing is dominant. Popular building styles have very high thermal conductivity and all but the most expensive villas would meet the national codes for roof and wall U-values. Houses are excessively hot for these reasons. An unavoidable conclusion is that the built environment, by form and function, is a direct cause for poor levels of comfort demanding high use of air conditioning and high energy usage. Even government attempts to promote vegetation around homes, which could mitigate some of the design and structural problems, is not working. The dominance of concrete and stone also means buildings are inherently high in embodied-energy and the popularity of facial stone means buildings are also very expensive. Admittedly normative values underlie these style and aesthetic choices.

8.3 Better alternatives: 'Beige' Buildings are Highly Feasible

Results show that a wide array of techniques exist to improve building performance. Through application of basic principles; namely priority selection of local resources and careful minimisation of resources combined with minimising heat gain and maximising heat rejection; buildings in Aqaba-type conditions could provide a more attractive and comfortable built environment at lower environmental, economic and social cost. The simplest first-step options to take advantage of the opportunities that present themselves are clear:

Use of local earth and stone materials that are readily available is likely to lower material and transport costs while opening new opportunities for material suppliers and connected job opportunities.

Use of grey-water recycling in the home for toilet flushing and direct irrigation represents an immense opportunity to substantially lower water use, enable shade vegetation to be grown around buildings (reducing cooling loads) and increase the aesthetic value of Aqaba.

An emphasis on insulation and north-south orientation for wind and sun in buildings would reduce cooling loads by reducing thermal gain, increase summer heat rejection and natural evaporative cooling potential. This would have a major impact on reducing peak electricity demands from air conditioning.

As results show, these changes demand a first-cost premium. However, the higher first-costs calculated which are based on skeleton to skeleton comparisons mean that as a percentage of total finished building costs, this percentage (10%) is likely to be substantially lower. The payback period on this additional investment are very small compared to the 10 to 20 year occupancy lengths common in Aqaba (Hanna, 2005) and would be further reduced by the trend to higher fossil fuel prices when these are translated to higher electricity costs.

8.4 Promoting Change: Overcoming the barriers to innovation within the built environment

Within and between the Aqaba building industry, ASEZA and the general Aqaba population, multiple phenomena exist that act to retard potential change in the built environment. These 'negative' forces are complementary and pervasive, emerging in regulatory, institutional, commercial and social decision making and will entrench the persistence of the building status quo if left unchallenged. This section presents a brief discussion of how each of the main phenomena acts as barriers to the adoption of 'Beige' Building techniques and analyses why these phenomena exist.

It is useful to approach the challenge of introducing 'Beige' Buildings into the ASEZ as a 'diffusion of an innovation' issue. Since on both the supply and demand side of the built environment, Beige buildings constitute an innovation by being both "...an idea, practice, or object that is perceived as new by an individual..." (Rogers, 2002) and "new production units, machines, processes, and techniques adopted by firms..." (Brown, 1981) In (Frambach Ruud, 1993).

(Rogers, 1995, 2002) presents a basic diffusion of innovation theory model that identifies five characteristics as being the main determiners of diffusion of new ideas, techniques and methods. In his opinion the higher the perceived advantage of the innovation, the level of consistency it has with potential adopters' needs and values and the greater the ease with which it can be observed and experimented with, the more likely it innovation will become

widely adopted. Conversely, the higher its' perceived complexity will act against its adoption (Rogers, 2002). The degree to which these five characteristics exist and affect the adoption of Beige buildings can be explained by phenomena identified from field research in Aqaba. These phenomena describe in part why the buildings of Aqaba are designed with complete disregard for the region. Identification of these phenomena also bring to light underlying factors that support their existence and suggest why buildings will continue to be built the way they are while these underlying factors remain unchanged. The five characteristics and related observed phenomena are seen in Table 8-1. The identified phenomena and their causal factors are analysed further in the five following sections.

Table 8-1 Phenomena Influencing the Diffusion of Beige Buildings in Aqaba

Characteristics regulating innovation diffusion of Beige buildings	Observed phenomena upon which these characteristics depend	Evaluation
Perceived Complexity of alternative buildings	Low level of awareness Low level of knowledge Limited experience Social influencing factors High level of real change required	High
Perceived advantage of alternative buildings	Positive perception of status quo Negative perception of alternative Perception of high cost of alternative	Low
Perceived consistency of alternative buildings with existing needs, values and experiences	Unclear perception of current needs Unclear perception of what alternative is Strong aspiration for 'modernity'	Low
Observability	No examples exist No promotion of experimentation is done	Nil
Trialability	Substantial capacity barriers Limited regulatory barriers Slight first-cost barriers	Dependent on Actor

8.4.1 High Perception of Complexity

The general impression in Aqaba is that alternative building concepts are highly complex and difficult to understand. Interviewees expressed the opinion that high levels of skill and new 'hi-tech' equipment were needed. Others found it difficult to understand how multiple alternative building techniques could be integrated. Low levels of awareness, knowledge and experience, combined with a general social aversion to trying new ideas were all explanatory phenomena linked to this high perception of complexity.

Level of awareness is a critical factor that influences perceived complexity. Level of awareness of a concept inherently reflects familiarity with it and in-turn can influence its level of perceived complexity. Having knowledge of a 'new idea' is considered the first requirement in the innovation-diffusion process (Rogers, 2002).

The following factors act to perpetuate the low level of awareness of alternative building styles in the ASEZ.

- No Beige building examples exist: There is no direct input of alternative building ideas into the building industry or into the collective understanding of the ASEZ population.
- Limited experimentation within the building industry: thus there is less opportunity for new ideas to be exposed in real, physically identifiable examples.
- No medium for promoting or sharing experiences between professionals exists when experimentation does occur.
- No effective leadership from either the engineering association or ASEZA on training, public outreach or mechanisms for public education on alternative building styles

Once awareness exists, the knowledge of an innovation provides potential practitioners and users the ability to make a more accurate assessment of what is required to adopt the new idea. Since alternative buildings demand more of an operational and cultural shift rather than technological change from conventional buildings (Hes, 2003; Rochracher, 1999) it can be expected that a higher level of knowledge is likely to lower people's estimate of 'Beige' Building technical complexity. Conversely peoples' perceptions of the operational complexity required may increase as a result of more knowledge. Interviewees' perceptions of 'Beige' Buildings revealed a distinctly low level of knowledge and can be attributed in part to the following observed factors.

- Poor training & no training opportunities for Beige building
- Lack of leadership from the local engineering association
- Little evidence of industry Research & Development
- No public outreach or mechanisms for public education on these issues

Perceived complexity of a new concept can also be thought of as a function of experience with it. Interviewees that indicated some level of understanding on energy efficiency issues for example, expressed the difficulty of maintaining that knowledge because they never applied it.

The lack of practical experience with alternative techniques can be linked to:

- The lack of market demand for alternatives
- No regulatory pressure to apply basic elements of energy and material efficiency.

8.4.2 Low Perception of Advantage from Change

Results show that interviewees (excluding some ASEZA professionals) rarely expressed an opinion that change was needed in the built environment. In this context, there is clearly very little advantage perceived from 'Beige' Buildings. Aqabanain's perceptions were largely positive toward the status quo and predominantly sceptical toward any alternative building concepts. The adoption of any beige building innovations is unlikely in this climate.

As social influence generally ensures conventional ideas endure (Kincaid, 2004) it is likely that a potential adopter in Aqaba would need to have a low or negative perception of the status

quo in order to perceive an overall advantage from adopting alternatives. Except for a general frustration at the high costs of building, the opposite appears true.

Factors supporting the positive perception of conventional built environment are:

- The connection between concrete, big glass windows and the widely aspired perception of ‘modernity’
- The perceived connection between newly built Aqaba buildings and housing styles of Amman
- The high value placed in social status of buildings, expressed as minor variations in the conventional style
- Nothing to compare the status quo against

The generally negative perception of alternatives can be traced in part to:

- A link between some alternative building materials (earth and straw) and traditional buildings which are considered ‘old-fashioned’ and infer poverty
- A “*pattern oriented society*” wherein new ideas are ignored or disliked until they become established as successful
- The perception that ‘Beige’ Buildings take much longer to build compared to conventional styles
- A perceived link between alternatives and a negatively viewed ‘Western’ influence
- Limited knowledge and experience of what Beige buildings mean in reality

The high perception of alternative building costs is also a phenomenon that acts against Aqabians seeing an advantage in innovation. The following factors promote this perception:

- Fundamental features of Beige building (such as high thermal performance) are not considered essential by the building industry or their clients and thus perceived as an expensive “luxury”
- Low awareness and knowledge leading to conceptual gaps in clients’ perceptions of the status quo (for example the missing link between building design and cooling costs)
- New ideas are automatically considered complex and risky by the building industry
- The majority of Aqabians are financially vulnerable to risk and scared of change

8.4.3 Perceived consistency with needs, values and experiences

People in Aqaba appear to have an unclear perception of how consistent ‘Beige’ buildings are with their current needs, values and experiences. This is not surprising since the current built environment seems to be proliferating outside a strong tradition of endemic building styles.

Furthermore, there is a widespread lack of awareness of what alternative buildings would mean in reality. Other phenomena such as a lack of environmental concern and the strong aspirations for high-status concrete-block 'modernity' suggest perceived consistency between public needs and values and Beige building is low. The positive perception of traditional buildings as cool and functional (if old fashioned) serves as one area where alternative buildings are seen as consistent with needs and past experiences.

The lack of entrenched local traditions in the built environment combined with an external focus on Amman or Dubai for inspiration suggest that a clear lack of identity permeates decision making on the Aqaba built environment. Without a strong sense of common identity it is difficult to imagine decision makers developing a cohesive strategy for the local built environment. Hence the proliferation of non-organic styles and a heavy focus on transient values such as status and image.

The phenomena just described can be attributed in part to the following factors:

- A predominantly immigrant population who bring values of the built environment that are alien to Aqaba's socio-geography
- A high number of externally based or trained industry and authority decision makers who bring values of the built environment that are alien to Aqaba's socio-geography
- The growing trend of speculative real estate investment in Aqaba that is geared toward short-term high profit returns rather than values of functionality

The lack of awareness and poor knowledge of what 'Beige' Building can provide is a glaring problem that prevents Aqabians from making the comparison between this higher quality alternative and what they know. It can dramatically influence demand and the perception of Aqabians on the values of the status quo. In reality, the benefits of reduced cooling and material costs to be found in 'Beige' building are totally congruent with the needs of Aqabians currently complaining about their electricity bills. A chronic lack of awareness and knowledge which limits most buyers from making the link between building designs and cooling cost represents a major market barrier and a barrier to effective policies. As Stave (2003) notes, stakeholder support for a policy is more likely if the underlying causes of the problem are understood. In Aqaba they are clearly not. Lack of awareness can be traced to many factors, some have been outlined previously. Key factors ensuring this lack of consumer awareness continues are:

- The absence of any example 'Beige' Buildings in Aqaba
- The absence of any medium through which new ideas can be exposed
- Poor building industry awareness to the fact that energy efficient building matches a growing market need

While adoption of 'Beige' Buildings would not necessarily reflect that its adopters have a high level of concern for the environment (remembering social and economic benefits exist also), the general lack of concern for the environment in Aqaba indicates that attitudes held by potential adopters rule out 'Beige' building diffusion riding on environmental values. Wanting to avoid the highly complex maze of what influences people's norms; I suggest that at least the following three factors present in Aqaba help perpetuate this inconsistency of values noted. These are:

- No public education of how buildings impact on the environment
- Little awareness of resource limitations and the consequences of resource over-exploitation
- No sense of personal connection to the natural environment

8.4.4 Level of ‘Observability’

As an innovation with potential for high level public and industry observability, ‘Beige’ buildings could not have better characteristics for achieving widespread exposure. They are large, have universal appeal and can be displayed in highly public ways. However in Aqaba they simply do not exist and thus they are not observable. This phenomenon is thus a function of all the barriers hitherto outlined. Special attention should be given to the lack of outreach and unfinished attempts to increase exposure of building innovations within the ASEZ. Failure to follow up on building design competitions with commissioned projects and failure to publicise competition results has meant exposure opportunities have been wasted in the ASEZ.

8.4.5 Degree of ‘Triability’

‘Beige’ buildings are an innovation that cannot be trialled easily by individual households in Aqaba. The low level of awareness and capacity, the current high cost of land and construction and the rigid, unimaginative nature of client demands will all act to reduce likelihood that experimentation driven by individuals can occur in Aqaba. However, the local industry players show a strong interest in the idea of building experimentation if the money exists and the general public are also interested in the idea of a trial; yet they both feel that they are not in the position to initiate such a project.

In the Aqaba context, the challenge of experimenting with ‘Beige’ building should not be a problem for institutions such as ASEZA, large developers or business investors. ‘Beige’ building needs a champion to ‘break the ice’. The business case exists as does the capacity; all-be-it outside the ASEZ. Any additional first costs need to be viewed in the context of being a business investment. This is much more in-line with commercial thinking than householder attitudes and more needs to be done to promote this perspective.

8.5 Contributing Contextual Problems

The argument has been made that the spread of ‘Beige’ Buildings in Aqaba depends on the strength or level at which normative, cognitive or structural factors influence observed phenomena undermining the five characteristics of diffusion. Unfortunately the situation is not as simple. The diffusion of innovation framework presented does not factor in other important social and regulatory forces. These forces do not necessarily lie outside the realm of innovation theory and research however, but should be seen as shaping the contextual environment in which the diffusion process may take place.

8.5.1 Institutional Barriers

There are glaring symptoms suggesting that efforts to change would be undermined by institutionalised ways of behaving and thinking in the ASEZ and not just by the phenomena discussed in section 8.4. Many of the phenomena reflect, or are themselves, institutional behaviours: established ways of doing things that appear to have become “*taken for granted through repeated use and interaction*” (Clemens & Cook, 1999). Strategies to overcome the factors

retarding diffusion need to address institutionalised behaviours as well as their symptom phenomena.

The culture and norms under which people and institutions operate are oriented in the opposite direction to what is needed for 'Beige' building to become mainstreamed. The attitude of 'minimal price at all costs' combined with a higher value placed in building status over functionality for example, is completely incongruent with the long-term focus and principles of efficient resource use lying at the heart of alternative building. Stakeholder integration also lies at the heart of the holistic design and construction approach that both high quality building (Construction 21, 1999; Dulaimi et al., 2002) and Beige Building requires (Hes, 2003; Rochracher, 1999; Novelli, Pers. com). Instead of integration, interaction on decision making in the Aqaba built environment is deeply affected by a culture of mutual distrust and little desire for understanding between stakeholders. The cost-cutting and downward wage pressures placed on building employees and sub contractors in Aqaba reflects a culture that (Nicolini et al., 2001) describes actually strengthens adversarial cultures and reduces transfer of information between firms. Since propagation of new concepts is as integrally linked with social interaction (Loosemore, 1998) and the strength of social networks (Rogers, 1995), this adversarial culture also has a direct impact on diffusion of innovations and strengthens industry inertia. The message is clear; in addition to a higher public appreciation of building function and a shift away from values of extreme profit maximisation, a cooperative and highly interactive culture between stakeholders is clearly needed in Aqaba. In these conditions, Nicolini et al., (2001) argue for collaboration and 'relational' forms of contracting to break the lack of cooperation. Larger firms, industry groups or regulations could push this, but leadership is missing.

Promoting a shift in norms and behaviours is not the only step required. Even if existing adverse norms were overcome, capacity restraints exist. Most professionals in Aqaba do not understand alternative building design, or any form of 'Beige' Building methods that could facilitate a mainstream 'change for the better'. Others have clearly wrong ideas while their colleagues that do express some knowledge are shackled by lack of practical experience. Furthermore, there are no training opportunities or leadership in this field from the local branch of the National Engineering Association. The local industry is also comprised predominantly of small scale firms, a characteristic attributed to low investment in research and development (Oster & Quigley, 1977). Awareness and practical knowledge needs to be met with opportunities for training and application. Given that many professionals expressed a personal interest in the concept of 'Beige' building and that knowledge and opportunities for training exist within Amman, overcoming capacity barriers should not be difficult once demand exists. This demand needs to be strong however, since numerous researchers have highlighted the intransigence of the building industry world wide to adopt new ideas. This intransigence has been linked to many of the characteristics described in this study such as adversarial cultures and fragmentation (Koskela & Vrijhoef, 2001; Oster & Quigley, 1977; Winch, 2000).

Where there needs to be a strong demand there is not even an emerging one. Chapter 6 has shown that cost incentives for some elements of 'Beige' building do exist and other alternative building elements bring added benefits. People are simply not aware of this fact however and this needs to change. Such a heavy stress on first-cost in building decision making means that awareness alone is not likely to be incentive enough. Other incentives are needed to promote the first steps, to overcome fears of risk and first-cost hurdles (Powell & Craighill, 2001).

Even if the capacity and demand existed and some 'innovators' took the step of commissioning the first 'Beige' buildings, success is not necessarily guaranteed. No standards

exist by which designers and builders can benchmark projects. No demonstration examples exist from which costs can be compared. Furthermore, no laws define minimum requirements and no checking and enforcement mechanism is in place that has the confidence and respect of the public and building industry.

The Role of ASEZA

ASEZA needs to play a leading role in driving a 'change for the better'. It is a major stakeholder and represents the local population. It also has direct links to the national authorities and is the final regulator. ASEZA also has access to professional services that other institutions in the ASEZ do not have. Significant problems exist with ASEZA taking a leadership role in driving change however; a problem of trust and legitimacy. As studies by numerous researchers and change 'gurus' stress, collaboration and trust is an essential component of leading change and innovation (eg. see (Cebrowski, 2005; Hattori & Lapidus, 2004; Kotter, 1996; Kouzes & Posner, 1995)) which is in turn linked to perceptions of respect and legitimacy and characteristics such as honesty and transparency (Kotter, 1996; Simons, 1999; Tobin, 2004). These features are largely missing or perceived to be missing from ASEZA by other built environment stakeholders.

Symptoms of deeply uncooperative relationships between ASEZA, players in the building industry and the public emerge as disrespect, arrogance, avoidance of responsibilities and even antagonism. They play out as an ASEZA siege mentality, highly competitive cost-cutting in the building industry and a popular distrust and lack of awareness of what ASEZA plans with the built environment. These don't appear to be recent phenomena. In Fahmawi's analysis of the systemic lack of cooperation existing in the ASEZ, fear of change, short-term oriented thinking and an underlying current of stress stem from problems in Israel and Palestine. More recent layers of antagonism to regulations stem from the inorganic nature of the ASEZ and ASEZA with locals having no say in the authority's formation and most primary decision makers coming from outside the zone (Fahmawi, Pers. com.).

The frequency of building code abuses by public and industry alike, suggest that the antagonism to laws and the '*fooling of ASEZA*' is an established norm within the ASEZ community. It is evidence of little honesty and poor transparency. These behaviours are matched by ASEZA's lack of public outreach, paternalistic attitude and other symptoms of what appear to be an institutionally accepted 'castle-on-the-hill' approach to regulating the ASEZ. Mutual distrust between built environment stakeholders is undermining the current process of enforcing even the small number of local codes in place while disregard for building regulations and laws appears thoroughly systemic. From ASEZA employees justifying why national building codes are never followed in residential homes to contractors who have developed elaborate methods of deception to avoid code requirements and their clients' demands to cutting costs; avoidance behaviour appears normal.

While many criticisms made of ASEZA code enforcement appear evident of deluded conspiracy theories, others quite justifiably question ASEZA priorities. Why the emphasis on building colour for example, when no attempt at enforcing thermal compliance occurs? Why the emphases on zero discharge from small industries when everyday, highly visible pollution of the gulf occurs from port loading of processed rock phosphate? With many people believing that ASEZA priorities are weighted more in favour of breeding an image to attract new development than on environmental protection, building a sense of community or increasing resource use efficiency, it is difficult for ASEZA to push these values. It would not be viewed credibly. Legitimacy is also a problem because ASEZA is seen to be pushing values and ideas that are different from those of the ASEZ community, and in fact many of

the environmental and collaborative values underpinning 'Beige' buildings are not aligned with those of many stakeholders. ASEZA has a legitimacy problem which desperately needs to be rebuilt before it can be respected as a driver of change in the built environment (Dowling & Pfeffer, 1975 In Zahirul, 2005). In this environment, ASEZA needs to be seen to practice what it preaches and lead by example.

Yet the problem is not merely an internal one. If ASEZA were to provide information through channels of communication more used to avoiding conflict or demanding obedience to regulation, they are more likely to fail. Not necessarily by lack of will but by the unaccustomed familiarity of ASEZA employees to work information mediums that are respected by the target audience. This speaks of an institutional capacity problem within ASEZA that prevents it from engaging with the community in a meaningful way.

As (Barker, 2004) describes, legitimacy and credible transmission of new ideas and values often comes from community leaders. Similarly (Rogers, 2002) stresses that attitudes to innovations are best changed through social interactions. This is exactly the point that community development officer Shamuh (Pers. com) makes. According to her experience with low income communities in Aqaba (within which she also lives), ASEZA's normal way of dealing with issues will not be useful for promoting the 'Beige' building concept; "*literature and meetings are not effective*". Instead she strongly believes "*The people need to drive this [process]*" and suggests that "[people need] *local community groups and simple symbols and stories*". A bottom up process would be unique to the ASEZ.

If attempts are not made to alter some of the 'patterns of behaviour' that have become part of the "*...character of organisational practice*" within institutions in the ASEZ then attempts to drive change from those institutions which are contributing the problems in the first place will not be so effective.

8.5.2 Regulations as Barriers

Local regulations should present no significant hindrance to 'Beige' buildings. They take a generally un-prescriptive approach to materials and designs which would constrain Alternative residential buildings and even suggest the use of local materials such as Rammed Earth. Looked at in another way the lack of prescription also means that the building market is propagating in a regulatory vacuum regarding design for the environment. The lack of enforced guidelines or standards relating to basic measures such as building thermal properties, resource use or orientation is allowing other forces (which appear to be mainly economic and social status values) to dictate the direction and behavioural boundaries within which the built environment develops. In this environment, rather than facilitating the emergence of buildings with heterogeneous characteristics as Clemens & Cook, (1999) suggests would occur in the absence of strict rules; the absence of any prescriptive institutional pressures on and in the construction industry to increase energy efficiency has led to a very homogeneous poor quality building stock because the pressure to reduce construction costs is so strong. While arguments have been put forward suggesting building codes are often a retarding factor in the building industry (Oster & Quigley, 1977), it is important to remember that well defined codes can play a role in defining benchmarks and minimum standards. These can help provide important direction for industry.

A core problem in the building regulations is found in Article 33 B-1, in which requirements for insulation and climatic orientation are undermined by the clause "*if possible*" (Aqaba Special Economic Zone Authority, 2004). This provides a loop-hole through which developers and owners can avoid insulating buildings or orientate for the sun and wind. The

regulations also lack practical meaning to building professionals who probably don't have experience with design for orientation and desire guidance on thermal values. Without supportive codes specifying minimum envelope thermal properties or direct reference to the national codes, local regulations provide no guidance on benchmarks and minimum standards. Considering disparaging attitude of ASEZA professionals to the national codes, it is highly unlikely that building professionals would have a better opinion.

ASEZA is in the unenviable position of not having much flexibility to provide incentives for change. Reducing taxes and charges are not likely to be incentive enough since the ASEZ low tax and duty free status gives little room to selectively cut building costs through tax reform. Neither will reducing application times which are short anyway (11 days). It is not known what financial resources ASEZA has to offer impressive subsidies, rebates or grants but with local revenues from taxes and charges being low, this is assumed to be more dependent on external funding bodies.

Considering the marginal improvements gained from voluntary building improvement schemes in other countries (Lee & Yik, 2004), opting for voluntary mechanisms would not be a smart choice. In light of the building industry's ambivalence, lack of awareness and poor capacity to implement Beige building, to do so would be fanciful. Relying on only prescriptive laws is also likely to fail. Changes in the regulations are required but in light of the widespread disregard for the national codes, much stricter checking and enforcement mechanisms are needed. Introducing these will be a social balancing act dependent first on changing social and institutional attitudes.

Building regulations that reflect the regions' scarce resources are not understood, appreciated or enforced in the ASEZ. The factors undermining existing laws are both technical; the lack of training, and institutional; the attitude within ASEZA that abuses are inevitable, the on-site cost-cutting and the culture of chronic disregard for regulations in both the demand and supply market. These forces appear to have developed from a combination of low compliance enforcement, a local cultural antagonism to regulations, the current 'gold-rush' mentality in the construction sector and the intense pressure that high land and construction prices are placing on clients.

8.6 Opportunities

In contrast to the negative factors discussed in the previous section, there are some positives. The changing demographics of the building demand market toward more wealthy buyers presents opportunities for ASEZA. Speculative investors more likely to respond to:

- a) Clear arguments for the cost advantages of Beige building
- &
- b) Prescriptive regulations and building codes,

for the simple reason that they will have greater financial flexibility and a better understanding of return-on-investment concepts. Targeting stricter regulations to apartment buildings (which investors and more wealthy clients are more likely to build) may thus meet with more success. This sector of the building stock also appears to be growing and will thus be demanding a greater proportion of resources and placing more stress on the region in the future.

As Rogers, (2002) argues in his discussion of innovation diffusion, it is easier for diffusion to occur if potential adopters see problems with what they have and view alternatives positively. If this does not exist, educational or informative tools are seen as crucial to overcoming such normative barriers Rogers, (2002). Opportunity exists for harnessing the public's few concerns over the current building market that relate to high costs, low aesthetic quality and the importance of status. Creating the perception in the housing market that 'Beige' buildings are synonymous with the high-end quality market may prove one fertile avenue for education and marketing. Similarly, the positive link made between alternative buildings and old traditional rural buildings by people in all levels of Aqaba society suggest successful promotion strategies may involve presenting 'Beige' buildings as a 'return' to the traditional. As noted by Clemens & Cook, (1999) this specific tactic has been applied by many innovators who "...cloak their efforts for change in appeals to restore tradition". However, the pervasive public perception of some alternative building materials is that alternative buildings are also "old fashioned" which puts them at-opposites to people's aspirations for 'modernity'. Consequently, promotion of 'Beige' building will need to be more subtle in drawing links to 'outdated' traditions and must clearly emphasise design for environment as emerging state-of-the-art but with all the benefits of tradition. One clever approach to making this link may be to draw public attention to Dubai's efforts on energy efficiency (eg. see UAE Ministry of Information and Culture, 2004) since Dubai is locally viewed as synonymous with modernity.

Some members of the building industry appear interested in the concept of Beige buildings. They appreciate the concepts but want to see it work. Likewise, members of the public like the idea of having a physical understanding of what 'Beige' buildings' can mean for them. The fact that people suggested and clearly liked the idea of having a demonstration building that they could access, suggests this approach may be fruitful. The public response to copy elements of the stone SOS-Childrens' Village after it was built, also suggests, a lack of local identity could act as fertile ground for implanting new ideas. Getting real buildings on the ground may do this, particularly if the public and industry are involved and given access.

Strategies to promote 'Beige' buildings must come at all levels to counter systemic barriers that are normative, cognitive, structural and institutional. Care must be taken to address poor knowledge, misaligned values and bad perceptions that act against diffusion of this innovation. Any strategy forward must also recognise that these factors reinforce and are themselves reinforced by behavioural patterns within the ASEZ. Within ASEZA, the building industry, the contractors themselves and particularly the public's behaviours toward government illustrate that the ASEZ 'way of doing things' appears in complete misalignment with the collaborative and integrated cultures deemed necessary to bring successful Beige buildings into the mainstream. Additional or more specific prescriptive laws to prevent poor building construction and design are needed. However, these must come a complementary second to mechanisms that facilitate collaborative decision making between stakeholders on the built environment, improve greater industry capacity and encourage community driven leadership on the need for alternative building styles. Pushing 'Beige' buildings from the 'top' will not prove fertile on its own.

9 Conclusions and Recommendations

Aqaba faces a major challenge in improving the performance of its residential building stock and better adapt to the hot, arid and limited resource environment in which it is growing. In exploring the status quo, alternative options and major hurdles in taking an alternative building path, results have shown that dramatic change is a social and economic imperative. The glaring realities of problems that exist and the technical simplicity with which they can be improved have demonstrated this imperative.

Opportunities for raising the social, environmental and economic performance of the residential building stock exist in all fundamental aspects of building design and composition. The Aqaba building stock has huge capacity for improvement. However, the opportunities will remain 'unpicked' if the systemic social and institutional barriers to alternatives that exist are ignored. Changing normative attitudes through a bottom-up approach to community attitudes will likely be the most difficult barrier to overcome and yet will probably bear the best results if done successfully. A difficult task lies for ASEZA as the major stakeholder. Deeply undermined by chronic legitimacy problems, ASEZA's task of facilitating change will involve a clever balancing act that may easily come undone if it underestimates the need for a collaborative approach.

It cannot be stressed enough that action on these issues need to begin now for future crises to be mitigated. Left to its own devices, future housing markets will no doubt react to increasing energy and water prices and demand adjustments to mitigate these costs. Some degree of improvement will come. Future stress will be felt greatest by the Aqabian poor however, far more than they feel it at present. Having no financial flexibility to make adjustments to buildings after they are constructed, they will be locked onto a 'treadmill' of high resource consumption and high costs because of their poorly conceived buildings. A continuation of the poor status quo will only ingrain poverty within the ASEZ. The social cost of this result will be far higher than any first-cost premiums paid now to reduce building energy and water use.

While cost imperatives may act to reduce per capita water and energy demand, this thesis has pushed that improvements can be made at a far broader level by taking an integrative approach to design and construction. Any market driven improvements are not likely to focus on such integrative measures and hence the need for a multidisciplinary array of tools for successful propagation of Beige buildings. As yet, no one has taken up the challenge of showing what benefits can come from such integrated thinking.

Successfully leading the Aqaba building stock away from its highly unsustainable route to create a built environment that is comfortable, a minimal consumer of resources and that is also organic: reflecting both the geography and the people, will do far more to place the Aqaba on the world map as a forward thinking and innovative centre than any other investment decision. Such a move would directly benefit all business in the ASEZ and show leadership in a region desperately needing courage in this field. Furthermore, it would make a strong signal that the Aqaba taskforce mandate of "*enhancing the quality of life and prosperity of the Aqaba community through sustainable development*" is more than clichéd rhetoric. The strength of will remains to be seen.

9.1 What Needs to Change

The following points are used to highlight the depth of problems facing any efforts to promote Beige building in Aqaba. It can be used as a checklist against which mechanisms should be evaluated. The core problem areas needing change are that:

- The culture of mutual antagonism, distrust and disrespect between the Aqaba public and ASEZA needs to be replaced by a culture of mutual understanding, benefit and cooperation.
- The focus on short term profit by speculative real estate investors must be countered
- The highly competitive construction process must be changed to a more cooperative and integrated one.
- Peoples' perceptions of traditional building materials and techniques as old fashioned must be replaced by an understanding that these materials can be high quality and something to be aspired to.
- Public perception that the current concrete dominated Amman style housing is the ideal must be replaced by an understanding that buildings need to reflect the local environmental conditions
- The ignorance of resource limitations must be replaced by a thorough understanding of how the built environment contributes to resource over-consumption and how 'Beige' Buildings can minimise resource use.
- All people in the ASEZ need to understand that 'Beige' buildings bring lower costs in the long term and don't mean substantial cost increases in the short term.
- The attitude that avoiding building codes is acceptable must be replaced with an understanding of how the building codes provide benefits.
- The building industry needs to be made aware that Beige Building represents an opportunity to increase skills and product quality.
- The building industry must increase the capacity of its workforce to apply alternative building techniques in a successfully integrated way.

9.2 Recommendations

An integrated array of complementary incentive, awareness raising, regulative and capacity building mechanisms is needed to introduce 'Beige' Buildings into the mainstream Aqaba building stock. Eight recommendations are presented which address the core problems and barriers identified in the ASEZ. They are all feasible; given the industry and political will to lay the foundations and to ensure maintenance. In the presentation of each recommendation the major stakeholders that could to be involved are noted and in some places reference to a tool or specific approach is made. Recommendations are presented in order of decreasing importance.

Commission demonstration projects

Demonstration projects will play an important role in changing public opinion and raising awareness. A demonstration building should not just be designed to showcase alternatives however. They should be carefully conceived to destroy negative social myths and help promote propagation of similar buildings by:

- Raising interest from community members most able to propagate similar buildings
- Facilitating learning from all stakeholders involved in the conceptual, design and building process (eg. through providing on-site training)
- Acting as a medium through which information can be disseminated to target audiences
- Acting as an icon building of community focus
- Raising perceptions of feasibility (cost effectively meeting or exceeding market demands)
- Generating a 'feel-good' factor during its creation.
- Ensuring potential adopters sense that green buildings do not require dramatic steps away from preferred conventional styles.

Possible options include public procurement or civic buildings such as community centres or mosques.

Another style of demonstration that should be considered is the use of projects on already occupied buildings. This would involve retrofitting a small number of existing residential buildings with alternative fixtures and 'add-ons'. For example: insulation, grey-water collection systems, double glazing, external shading devices and water and energy saving appliances and fittings. If done on a lottery basis but ensuring projects were fully dispersed throughout the population, this would result in major community awareness, raise potential for community discussion and immediately embed 'Beige' buildings within existing residential areas. This would provide a unique opportunity for socially facilitated awareness-raising.

Potential Key Stakeholders: Non Governmental Organisations (NGO's); Aid Groups; ASEZA; Industry groups; Residential construction firms: Charity and religious groups

Begin public education campaigns

Awareness raising and education is needed in the public arena to highlight:

- How decisions in the built environment influence Aqabianians in terms of high occupancy costs and environmental impact.
- The cost and thermal benefits of alternative building designs and local materials
- That the adoption of advanced building techniques means avoidance of future problems.

It is of critical importance to remember that often the best approach to this style of education is through community leaders, rather than to take a broad scale approach. The support of community groups and influential community leaders must be recruited to assist in process of awareness raising and overcoming normative resistance to new ideas. These non ASEZA-linked actors should lay the ground work for later involvement by the local authority.

Potential Key Stakeholders: NGO's, Aid Groups, ASEZA, Community groups

Conduct industry education and training.

Awareness raising and education programs within the building industry are needed to highlight:

- The problems with the status quo
- The business opportunities of 'Beige' building
- The likelihood of future enforced legislation that will prescribe improvements

Potential mechanisms include:

An adaptation of the Seattle City incentive scheme. This would involve funds being offered (under tender) for businesses wanting to build a minimum number of buildings that would exceed set minimum environmental standards. Competitive tenders would be decided by submitted plans. Winning contractors would be given the funds for exclusive use on integrated training workshops for the winning contractor and subcontractors on how to maximise environmental performance of the project. Upon building and meeting the competition requirements, the remainder of the funds would be provided. Upon failure to comply, the paid funds would have to be returned. (see: <http://www.cityofseattle.net/sustainablebuilding>)

- The development of industry (& public) information exchange networks and/or an advisory service funded through a industry levy
- Conducting best practice examples and/or competitions

Potential Key Stakeholders: Jordanian Engineering Association, Aid Orgs.

Integrate the public into governmental decision making.

Mechanisms such as public outreach programs are needed to integrate the population into governmental decision making on the built environment for the purpose of:

- Gaining a better understanding of what influences public perceptions on the built environment
- Reducing distrust and antagonism between ASEZA and the local population
- Sharing and aligning stakeholder aspirations
- Explaining proposed policy directions and their expected consequences
- Transmitting expectations for the public and industry to take greater responsibility

Potential Key Stakeholders: NGO's, Aid Groups, ASEZA

Set clear performance benchmarks for buildings.

Clearly defined environmental and standards are required that can be used for industry guidance and as a basis for further policy development. They should address as a minimum:

- Maximum water flow rates on taps and fixtures
- Envelope thermal properties
- Landscaping and Greenscaping
- Material use and sourcing

The LEED scheme may offer guidance or even an adaptable template to work from. Standards could also be seen as the first step in the direction of a labelling scheme

Potential Key Stakeholders: ASEZA, Aid Orgs., Jordanian Engineering Association, NGO's

Reworking regulations and compliance mechanisms.

Approaches to ensure compliance with regulations is needed. The required process will involve both an upgrading of the current checking and enforcement mechanisms and an increase in the institutional will within ASEZA to follow through.

Potential approaches could involve:

- Improved training of ASEZA staff on Beige Building principles compliance checking
- Using pre-construction bonds to ensure compliance with environmental requirements
- Flexibility with adherence to current code requirements (such as Floor Area Ratio & setbacks etc) in cases where advanced environmental performance and material characteristics are demonstrated

- Spearheading tighter regulations to speculative real estate, hotels and apartment buildings. This sector of the built environment offers greater potential for significant improvement. Potential approaches could include:
 - Specially tailored marketing and education focusing specifically on the business advantages and cost payback on investment from 'Beige' buildings
 - Tighter water and energy efficiency standards
 - Tying planning approval to commitments for long-term maintenance and covering partial cost of utilities

Changes to the building regulations should also consider the following for new buildings such as:

- Setting maximum window to wall area ratio's (WWR) eg. 0.1 to 0.15
- Restricting East and West facing WWR
- Setting minimum window, wall and ceiling U values (above National Code Standards¹)
- Promote underground living (eg. by not including underground living quarters in calculating building floor areas)
- Increase plot building densities allowed for buildings that include internal courtyards
- Requiring new zone developers to deliberately orientate land plots to the south

ASEZA should also consider the following issues in its decisions affecting the built environment

- Prioritising and selectively choosing shade vegetating on north-south oriented road verges to reduce solar gain to buildings from the east and west.
- Establish minimum environmental standards for all new government buildings
- Provide a mechanism for neighbours to contact each other (to facilitate back to back buildings)

Potential Key Stakeholders: ASEZA, Jordanian Engineering Association

¹ The Jordanian Building Research Centre is currently conducting research into redefining these values for the national codes, final decisions should be made in consultation with them.

Walk the talk

ASEZA needs to show very publicly that its aims are not rhetoric and that it is committed to the process of improving the built environment. Possible actions may involve:

- Setting up small monetary incentive programs
- Making further use of building design competitions by implementing results, principles and recommendations that arise from them and implement them through a demonstrative process
- Making 'Beige' building considerations a priority when planning and allocating lands, tendering for developers and maintaining existing streets
- Ensuring that public buildings are built to meet set environmental criteria and that the process and results are made public

(This does not mean taking away responsibility from the public!)

Potential Key Stakeholders: ASEZA

Market Beige building as part of modern Aqaba identity

Marketing programs are needed to promote the concept of environmental adaptation as being integral with the projected identity of Aqaba. Marketing approach could include:

- The use of keynote 'Beige' Buildings within the Aqaba built environment
- Selling 'Beige' Buildings to large business and real estate investors as being part of the strategic evolution of Aqaba (eg. as evidence of higher levels of customer service and quality)
- Making use of the distinction between an Ababa built environment dominated by Beige Buildings and a nearby high-rise Eilat with little or no environmental adaptation and few aesthetically distinctive features.

Potential Key Stakeholders: ASEZA, Aqaba Development Corporation

The next step is ultimately up to Aqaba and those who have a stake in its on-going development, thus it is recognised that the best choice of tools and stakeholders involved in their operation ultimately lies up to those with an interest and role in the development of the ASEZ.

9.2.1 Future research

The process of this research highlighted knowledge gaps and potential areas for future research that would benefit the improvement of Aqaba's built environment. Suggested future research would:

- Identify how general building work practices can be improved. The poor energy performance of buildings in Aqaba is heavily influenced by the quality of the finished work itself, not just the materials used.
- Make a cost and feasibility study of geothermal cooling and heating utilising the gulf as a heat sink/source for application in large coastal buildings such as hotels. A similar study should also be made into the application of wind towers in government buildings.
- Involve a detailed study assessing the risk and commercial application of utilising phosphogypsum by-products from the local phosphate plant as a building material. Gypsum is itself a major building product and has proven to be very successful in caste earth applications as an alternative to concrete and has better qualities than clay as a earth binder in earth walls (Anon., 2004).
- Draw from community consultation to develop a set of measurable indicators for a healthy, comfortable and desirable built environment.
- Identify building environmental and quality labelling schemes used in other countries that may be adapted to Aqaba conditions.
- Assess the feasibility of collecting and utilising storm water runoff for landscape and urban greening purposes.

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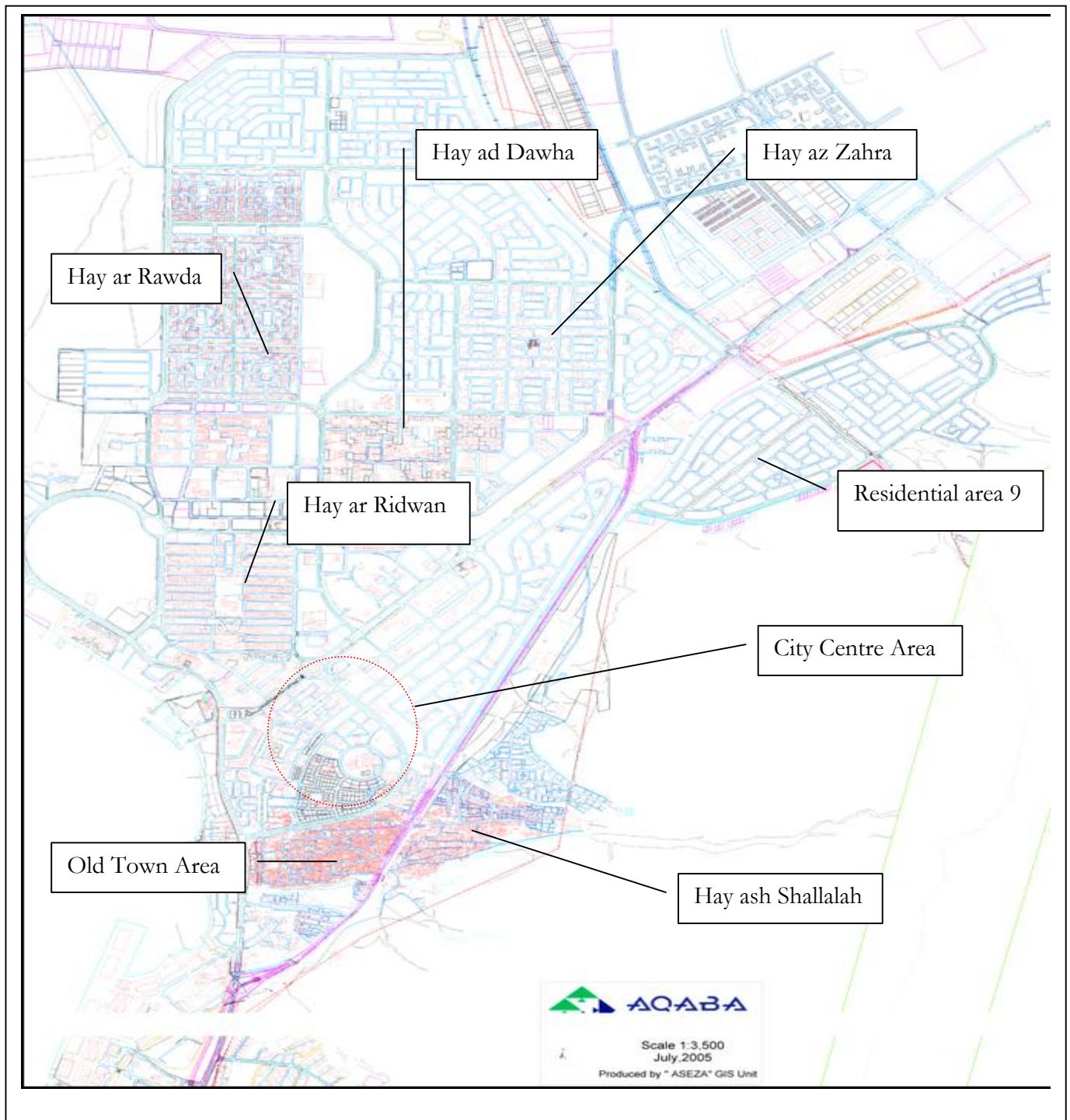
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Appendix 1: Aqaba City



NB: Walk-through surveys were done in the highlighted city areas

Appendix 2: Thermal Properties and Literature Sources

Source	Material	R-Value (W/m ² .K)
(Anon., 2005b)	10 cm Hollow block	0.141
(Northern Territory Department of infrastructure planning and environment, 2004)	20cm hollow block	0.350
(Australian Institute of Energy, N.D.)	10cm Poured concrete	0.070
(Australian Institute of Energy, N.D.)	20cm Heavy Weight C slab	0.140
(Northern Territory Department of infrastructure planning and environment, 2004)	2cm Plaster	0.040
(Clarke, 2000)	30cm Rammed earth	0.400
(Cummins & Stone, 1998)	40cm Straw bale wall	4.000
(Anon., 2005b)	10cm Expanded Polystyrene	2.770
(Marble Institute of America, 2005)	10cm Limestone	0.079
(Marble Institute of America, 2005)	10cm Granite	0.058
(Australian Institute of Energy, N.D.)	10cm Concrete render	0.070
(National Physical Laboratory, 2005)	10cm Aerated Concrete	0.270
(Australian Institute of Energy, N.D.)	External Air Layer	0.040
(Australian Institute of Energy, N.D.)	Internal air layer	0.140

Appendix 3: Thermal properties, cost and composition of Aqaba residential and commercial building wall styles

Wall type	Wall Composition	U- value (W/m ² ·K)	R-value (m ² ·K/W)	Quotations (Costs in Euro €) ¹			
				Saboba ²	Ravn ³	Haddad ⁴	Fahmawi ⁵
1	2cm Pl : 1x10cm HB	5.529	0.181	7.98	-----	-----	7.98
2	2cm Pl : 1x20cm HB	2.564	0.390	9.69	9.69	-----	9.12
3	2cm Pl : 1x20cm HB : 10cm C : 5cm Lst	2.010	0.497	-----	22.8	-----	28.5
4	2cm Pl : 2 x10cm HB : 5cm Air : 10cm C + 5cm T Lst	1.855	0.539	17.1	-----	-----	31.92
5	2cm Pl : 10cm HB : 7cm C : 10cm L st	3.282	0.305	-----	-----	-----	47.88
6	2cm Pl : 1 x20cm HB : 10 cm C : 20cm Gr	1.739	0.575	20.52	-----	-----	-----
7	2cm Pl : 1 x20cm HB : 3cm P : 10cm C : 5cm Lst	0.752	1.329	-----	-----	28.5	34.2
8	2cm Pl : 2 x10cm HB : 2cm Air : 3cm P : 10cm C : 5cm L st	0.746	1.341	10.83	-----	-----	37.62
9	2cm Pl : 1 x20cm HB : 5cm P : 10cm C : 20cm Gr	0.528	1.895	28.5	-----	27.1 to 52.2	-----
10	2cm Pl : 2 x10cm HB : 5cm P : 7m C + 3cm T lst	0.562	1.779	19.95	-----	25.08 to 51.3	30.78
11	40cm StwB : 16mm C Render : steel reinforcing mesh	0.242	4.131	-----	-----	18.696	-----
12	30cm Rammed earth	2.500	0.400	-----	-----	10.26	-----

NB: Where, Pl = Plaster; HB = Hollow block; C = Solid aggregate concrete; P = Expanded Polystyrene; Gr = Uncut granite stone; Air = Unventilated air gap; L st = Limestone; StwB = 3 string straw bale

¹ Quotes were obtained from the following contractors and material suppliers

² Saboba (Pers. com)

³ Ravn (Pers. com)

⁴ Haddad (Pers. com)

⁵ Fahmawi (Pers. com.)

Appendix 4: Material and physical characteristics of tested buildings

<u>Common Characteristics</u>																	
Floor area & roof area: 212 m ² ; Total air volume: 667.5m ³ Floor: Slab on Grade	Internal loads: 10 persons @ 67 W + 940 W for appliances and lights Internal temperature: 24 °C External (Design) temperature: 41 °C																
<p><u>Base Case</u></p> <p>Windows: Single glazed aluminium with internal shades Walls: 2cm Pl : 1x20cm HB : 10cm C : 5cm Lst Roofing: 2cm plaster + 20 cm Hollow block + 5cm concrete</p> <p><u>Minor Improvement Case</u></p> <p>Windows: Single glazed aluminium with internal shades Walls: 2cm Pl : 2 x10cm HB : 2cm Air : 3cm P : 10cm C : 5cm L st Roofing: 2cm plaster + 20 cm Hollow block + 5cm concrete</p>		<table border="1"> <thead> <tr> <th>Orientation</th> <th>Wall Area</th> <th>Window Area</th> </tr> </thead> <tbody> <tr> <td>N</td> <td>57.12</td> <td>6.75</td> </tr> <tr> <td>E</td> <td>48.28</td> <td>12</td> </tr> <tr> <td>W</td> <td>48.28</td> <td>12</td> </tr> <tr> <td>S</td> <td>57.12</td> <td>4.5</td> </tr> </tbody> </table>	Orientation	Wall Area	Window Area	N	57.12	6.75	E	48.28	12	W	48.28	12	S	57.12	4.5
Orientation	Wall Area	Window Area															
N	57.12	6.75															
E	48.28	12															
W	48.28	12															
S	57.12	4.5															
<p>Advanced Case</p> <p>Windows: Double glazed, aluminium with external opaque shades Walls: 40cm StwB: 16mm C Render : steel reinforcing mesh Roofing: 2cm Pl, 20cm HB, 7cm aerated concrete, 5cm sand, 5cm polystyrene, 2cm mortar, 2cm tiles. After (Al-Sanea, 2002)</p>		<table border="1"> <thead> <tr> <th>Orientation</th> <th>Wall Area</th> <th>Window Area</th> </tr> </thead> <tbody> <tr> <td>N</td> <td>57.12</td> <td>12</td> </tr> <tr> <td>E</td> <td>48.28</td> <td>6.75</td> </tr> <tr> <td>W</td> <td>48.28</td> <td>4.5</td> </tr> <tr> <td>S</td> <td>57.12</td> <td>12</td> </tr> </tbody> </table>	Orientation	Wall Area	Window Area	N	57.12	12	E	48.28	6.75	W	48.28	4.5	S	57.12	12
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NB: Where, Pl = Plaster; HB = Hollow block; C = Solid aggregate concrete; P = Expanded Polystyrene; Gr = Uncut granite stone; Air = Unventilated air gap; L st = Limestone; StwB = 3 string straw bale

The materials and dimensions used for the original construction designs were based on architectural plans given by Abu-Afifeh (Pers. com.) for a planned first floor apartment building. The designs were considered very typical of new Aqaba buildings in function, design, orientation and material components and were thus chosen for this respect. The only unusual aspect of its construction is the use of polystyrene insulation which is very rare in Aqaba residential buildings. The 'Worst case' was based on the most common construction materials used for similar buildings in Aqaba (ie. without polystyrene). The 'Best case' is built using superior wall, glazing and ceiling materials. Since the original construction was positioned with most of its glazing on the east and west facades, a 90⁰ degree clockwise re-orientation was used in the advanced case.

Appendix 5: Interviewees

Person	Organisation	Position in organisation	Date	Type ¹
Aboyeshe, K.	ASEZA		23/06/2005	I, SS
Aboyeshe, M1.	Building Engineers Association - Aqaba branch	Chief	28/06/2005	SS (t)
Aboyeshe, M2.	NA	PhD. Candidate Env. Engineer	02/07/2005	SS
Aboyeshe, K.	ASEZA		15/06/05; 05, 22, 24 & 25	I, SS
Abu Afifeh, A.		Architect & Engineer	18/06; 20/06;	SS
Abu Bakr	Building contracting company	Owner / manager	13/07/2005	I (t)
Abu Maitiq, M.	(Architectural & building contracting firm)	Architect & Owner / Manager	27/06/2005	I (t)
Abu Musa	Real Estate Agent	Owner / manager	02/07/2005	SS
Abu-Akhmed	Real Estate Agent	Owner / manager	13/07/2005	T, SS
Abu-Zahra, M.	Abu Zahra Constructions	Owner / manager	02/07/2005	I
Al- Dardasawi	Aqaba Water Company	Research & Design Engineer	08/07/05; 17/07	I
Al-Ajlouni, A.	Royal Scientific Society Aqaba Liaison Center	Head, Aqaba Laboratories	20/06/2005	I
Al-Asad, M.	CSBE	Director	12/06/05;	I, SS
Al-Asir, H.	Royal Scientific Society of Jordan - Building Research centre.	Researcher	12/06/2005	SS
Al-Deeb, R. K.	Arab Banking Corporation	Account Officer - Aqaba Branch	24/07/2005	SS
Al-Farajat, M.	Irbid Uni	Lecturer in Hydrogeophysics	26-Jun	I
Al-Haj, T.	Synergy Designs	Planner	12/06/2005	SS
Al-Hakim, F. S.	Chief of Aqaba Electricity Division	Electricity Distribution Co. Aqaba Electricity Division	19/06/2005	SS
Al-Husseini	Research and Coordination Officer	Research and Coordination Officer	12-Jun	I
Al-Jamal, I.; Al- Jamal, N	Real Estate Agent	Owner / Manager	06/07/2005	SS
Al-Smadi, B.	University of Jordan. Civil Eng. Dept.	Senior lecturer: Hydrology and water management	22/06/2005	SS
Al-Srouri, D.	ASEZA	Architects & Planners	05/07/2005	SS

¹ I : Investigative

S-S : Semi-structured

Tel : Telephone

E : Email

(t) : Translated

Person	Organisation	Position in organisation	Date	Type ¹
Al-Taher, A.	National Energy Research Centre – Rational Use of Energy & Solar Thermal Division	Manager	22/06/2005	SS
Al-Thaib, D.	ASEZA	Architects & Planners	05/07/2005	SS
Al-Zou'bi, K.	Aqaba Water Company	General Manager	19-Jun	SS
Awad, A. M.	Private contractor	Foreman	02/07/05; 05/07/2005	I
Dobrovolny, P.	Seattle City Light	Sustainable Building Development Officer	20/08/2005	E
Fahmawi, N.	Building Architecture & design firm	Architect	27/06/05; 24/07	I
Fsaifes, S.	ASEZA	Architects & Planners	05/07/2005	I, SS
Fsaifs, S. ; Haddaden, B.	ASEZA	Architects & Planners	15/06/2005	SS
Garaybeh, E.	Architectural and contracting firm	Architect	11/07/2005	I
Haddad, M.	Contractor	Owner, Manager	10/07/2005	SS
Hines, L.	Environment and Amenity, City of Darebin	General Manager	13/05/2005	Tel
Haddr, H.	Greenline Trd.	Manager	29/06/2005	Tel.
Ibraiwesh, M.	Ibraiwesh Contracting Co.	Owner Manager	23/07/2005	SS
Irtaish, S.	Petra Engineering Industries Co.	Sales Manager	24/07/2005	I, SS
Juma, T.	Millennium Systems for Advanced Technology	Head: Sales & Installation	11/07/2005	I
Khalil, M.	ASEZA	Environmental Director	16/06/2005	I
Khammash, A.	Ammar Khammash architects	Architect	21/06/2005	SS
Khrisat, H.	Petra Engineering Industries Co.	Aqaba Branch Manager (Engineer)	19-Jun	SS
Loans Manager	Royal Jordanian Bank	Loans Manager	19/07/2005	I
Maaitah, A.	Millennium Systems for advanced technology	Managing Director	28/07/2005	SS

¹ I : Investigative

S-S : Semi-structured

Tel : Telephone

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Person	Organisation	Position in organisation	Date	Type ¹
Mehyar, M.	Friends of the Earth - Middle East ;National Engineers Association- Environmental Committee	Chairperson	11/07/2005	SS
Nabulsi, A. F.	Aqaba Gulf Contracting Company	General Manager	08/07.05	SS
Najar, B. M.	National Engineering & Contracting Company	Aqaba Projects Manager	18/06/2005	SS
Nasser, K.	Jordanian Society for Sustainable Development	General Director	11/07/2005	I,SS
Nimer, A. N.	ASEZA	Acting Standards & Codes Division Head- Environmental Department	15/06/2005	I
Novelli, T.	Development Centre for Alternative technology	Assistant Director	15/05/2005	T
Novicell, J.	NA	Private Building Contractor	15/05/2005	T
Ravn, L. N	Scandevlop – Jordan Precast LTD.	20/06/05; 25/06/04	Engineer / company CEO	SS
Rousan, O.	ASEZA	Planning & Studies Director	17/07/2005	SS
Saboba, S. T.	Private contractor	Supervising Engineer	02/07/05; 05/07/2005	SS
Safi, I.	Radisson SAS Hotels & Resorts – Aqaba	Chief Engineer	03/07/2005	I
Saleh, N.	Aqaba Water Company	Customer Service Manager	08/07/05; 13/07; 17/07/2005	SS
Samman, A.	IDEAL solar technology systems	Manager	29/06/2005	Tel.
Sercan	Bektacoglu	Purchasing Officer	15/07/2005	I
Shamuh,	ASEZA	Community development officer	30/06/05;	I
Shawkh, O.	Local stone supplier	Owner / manager	13/07/2005	I
Smadi, A. M.	Smadi & Srideh Housing Company	Assistant manager	18/06/2005	SS
Tukan, J.	Consolidated Constructions	Architect	21/06/2005	SS
Visser, F.	Habitat for Humanity	Architect	22-Jun	SS
Zurekat, L.	Consultant	Landscape architect	11/07/05; 28/07	I, SS

¹ I : Investigative

S-S : Semi-structured

Tel : Telephone

E : Email

(t) : Translated

Appendix 6: Suitable trees and climbing plants for shading

Species	Habit	Water requirements
<i>Ficus retusa ssp. nitida</i>	Small to medium evergreen tree	Some summer watering
<i>Grevillea robusta</i>	Small deciduous tree	Minimal
<i>Ziziphus obtusifolia</i>	Medium to large evergreen shrub	Minimal
<i>Albizia julibrissin</i>	Deciduous tree	Watering required*
<i>Tamarix aphylla</i>	Large evergreen shrub	No watering depending on water table depth
<i>Nerium oleander</i>	Large evergreen shrub – small tree	Some summer watering
<i>Brachychiton acerifolium</i>	Semi-deciduous small tree	Watering required*
<i>Schinus molle</i>	Medium to large evergreen tree	Minimal
<i>Campsis Grandiflora</i>	Deciduous climbing vine	Summer watering required
<i>Bougainvillea glabra</i>	Evergreen vine	Some summer water required
<i>Plumbago auriculata</i>	Evergreen shrub/vine	Watering required*

NB: these are just a few selected species that are suitable for shading in Aqaba. All plants need watering while they get established.

* Ideal for grey-water irrigation