GUIDELINES FOR THE EVALUATION
OF BUILDING SYSTEMS IN THE
UNITED ARAB EMIRATES

by
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Submitted to the Department of Architecture on May 4, 1982 in partial
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in Architecture Studies.

ABSTRACT

The aim of this thesis is to explore the feasibility of an export-geared
building industrialization in the United Arab Emirates, and to develop
a tentative strategy for the implementation of such industrialization.

The United Arab Emirates (U.A.E), a rapidly growing country, is chosen
as the subject of this study, mainly because oil, which triggered the
wealth and rapid development, is regarded by the government as an
essential but temporary source of income; and a national policy to
diversify the country's industrial development is, therefore, being
pursued.
Industrialization of the building sector is advocated in this thesis,
as part of this diversification scheme.

The first chapter summarizes the situation in the U.A.E in terms of
geographical, vital, and economical statistics.
The second chapter outlines the components of the Alpha-Beta Model
(Grant, D.), the Method of Paired Comparison, and the Churchmann-
Ackoff Method for Weighting Objectives, as a formal means to evaluate
and define the most appropriate industrialization approach.
The third chapter applies these methods to the U.A.E's context, by
evaluating the "open systems" and the "closed systems" approaches
against selected objectives, derived for the data analysis.
The fourth, and final, chapter attempts to define a strategy for the
implementation of an export-geared building industrialization in the
U.A.E.

Thesis Supervisor: Dr. Eric Dluhosch
Title: Associate Professor of Building Technology
These words are a mere token of my appreciation to all those who have made this thesis possible.

I would like to express my deepest gratitude and respect to Dr. Eric Dluhosch, my thesis supervisor, who diligently provided me with his valuable knowledge and guidance throughout this work. I would also like to thank Mr. Ahmed Jassem Al-Abdouli, Under-Secretary, and Mr. Ahmed Al-Ghroobi, Assistant Under-Secretary, at the Ministry of Public Works and Housing in Dubai, for their generous help. I am also grateful to Mr. George Kadri and Mr. Hafez Alameh for their assistance in data gathering.

To Ed Robbins, Katy Dluhosch, Laura, the S.M.Arch.S. students and others too numerous possibly to mention (a standard formula, but true).

And last, but never least, to Abbey, for her love.
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Introduction
Like most of the countries in the Arabian Gulf region, the United Arab Emirates (U.A.E.) have experienced unprecedented change in the last 20 years. The discovery of oil, along with the energy crisis in the industrialized world, has created a great and unexpected wealth that triggered a rapid development process. The scale and especially the speed at which this process occurred have created the impression of chaotic and uncontrolled growth. A closer look, however, reveals that a steady and well-defined governmental policy has accompanied and monitored the country's development. The main motivation behind that policy is that oil should be considered an essential but temporary source of income, and that the economy cannot rely entirely on oil-related industries forever, and that a more diversified development must be pursued for the long run.

While this policy governed the majority of the economy's industrial sectors, it was more difficult to guide the building sector: the scale and speed at which the country's infrastructure had to be developed to provide a basis for general industrial development created a building industry that is far beyond the market's capacity to absorb, now that an adequate infrastructure is almost fully in place.

The hypothetical solution to the building industry's crisis seems, then, to direct that industry towards exports, as this would not only revitalize the building sector as such, but would also fit into the general framework of the government's policy of diversification of the whole economy.

The aim of this study is to verify the assumption that an export-g geared building industrialization in the U.A.E. is feasible and preferable to other options, and to develop a tentative strategy for the implementation of such industrialization.
I-The United Arab Emirates
a) Geographical and Vital Statistics

Situation

The U.A.E. is situated north of the equator, between 22° and 26.5° latitude, and 51° and 56.5° longitude, east of Greenwich Meridian. It is bordered on the north and northeast by the Arabian Gulf, on the west by the state of Qatar and the Kingdom of Saudi Arabia, on the south by the Sultanate of Oman and Saudi Arabia, and on the east by the Gulf of Oman and the Sultanate of Oman.

Area

The total area of the U.A.E. is approximately 77,700 km², divided as follows among the seven emirates:

<table>
<thead>
<tr>
<th>Emirate</th>
<th>Area (km²)</th>
<th>% of total area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abu Dhabi</td>
<td>67,340</td>
<td>86.67</td>
</tr>
<tr>
<td>Dubai</td>
<td>3,885</td>
<td>5.00</td>
</tr>
<tr>
<td>Sharjah</td>
<td>2,590</td>
<td>3.33</td>
</tr>
<tr>
<td>Ajman</td>
<td>259</td>
<td>.33</td>
</tr>
<tr>
<td>Um al-Qaiwan</td>
<td>777</td>
<td>1.00</td>
</tr>
<tr>
<td>Fujairah</td>
<td>1,165</td>
<td>1.5</td>
</tr>
<tr>
<td>Ras al-Khaimah</td>
<td>1,684</td>
<td>2.17</td>
</tr>
</tbody>
</table>

(Source: Ministry of Planning)

It should be noted that 70% of the area of the emirate of Abu Dhabi consists of desert.

Government

The area comprising the U.A.E. was under British control for nearly a
century and a half. This control was established in 1820 by a series of treaties, one of which was the "General Treaty on Maritime Truce." This gave the area the name of "Trucial States."

In 1968, the British announced their intention of withdrawal from the area. This set off meetings and negotiations between the rulers of the several emirates that were to last approximately three years. In 1971, two of the Trucial States, Qatar and Bahrain, achieved their independence. In July 1971, six of the remaining emirates decided to federate and establish the United Arab Emirates. These emirates were:

-- Abu Dhabi
-- Dubaï
-- Sharjah
-- Ajman
-- Um al-Qaiwain
-- Fujairah.

The seventh emirate, "Ras el-Khaimah," joined two months later. On December 2, 1971, the Federation of the United Arab Emirates officially came into being. The ruler of Abu Dhabi, Sheik Zayed Bin Sultan al-Nahyan, was elected president of the federation, and the ruler of Dubaï, Sheik Rashad Bin Saïd al-Maktoum, vice president. The federation is governed by a supreme council of rulers and a council of ministers, the latter formed on July 1, 1979.

Major emirates, cities, villages

Each of the seven emirates has for its capital a city bearing the same name as the emirate: the capital of the Emirate of Abu Dhabi is the city of Abu Dhabi, the city of Dubaï is the capital of the Emirate of Dubaï, and so on. Along with these seven cities, we find a number of minor cities
and villages, the latter comprising a total of around 336 villages.

b) Climate

The U.A.E. is situated in the subtropical arid zone and has a very harsh climate.

Temperatures

Temperatures vary between a yearly average high of 34°C (93.2°F) and a yearly average low of 20°C (68°F), with highs around 50°C (122°F) in June and July and lows around 10°C (50°F) in January.

Humidity

Humidity varies between a yearly average high of 65.6% and a yearly average low of 35.9%, with highs in the 90% in September and October and lows in the 20% in April and May.

Winds

The wind direction varies between south, southeast, and west; and north and northwest. The area is subject to quite frequent sand storms.

Rainfall

Rainfall rarely exceeds 150mm/year, although in 1979 a high of 390.1 mm/year was recorded, for a total of 39 days of rain. The rainy season is usually between the months of November and April, with half of
the total falling during the months of December and January.

c) Population

It is difficult to talk about the present population of the U.A.E., as there is no recent census, the last one dated 1975. Also, no figures can be found that would differentiate between the indigenous population and foreigners. Nevertheless, the following tables and figures should enable us to form a fair overall picture of the population situation.

The 1968 census states a total population of 180,000 inhabitants, concentrated mainly in the four largest emirates:

<table>
<thead>
<tr>
<th>Emirate</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dubaï</td>
<td>59,000</td>
</tr>
<tr>
<td>Abu Dhabi</td>
<td>46,000</td>
</tr>
<tr>
<td>Sharjah</td>
<td>32,000</td>
</tr>
<tr>
<td>Ras al-Khaimah</td>
<td>24,000</td>
</tr>
</tbody>
</table>

According to the 1975 census (published in February 1976), the total population was 655,937 inhabitants, again concentrated mainly in the same four emirates:

<table>
<thead>
<tr>
<th>Emirate</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dubaï</td>
<td>206,861</td>
</tr>
<tr>
<td>Abu Dhabi</td>
<td>235,662</td>
</tr>
<tr>
<td>Sharjah</td>
<td>88,188</td>
</tr>
<tr>
<td>Ras al-Khaimah</td>
<td>57,282</td>
</tr>
</tbody>
</table>

As for more recent figures, the only available population estimates were, as projected for 1978, 1980, 1982 and 1985:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>620,870</td>
<td>635,490</td>
<td>651,040</td>
<td>677,980</td>
</tr>
<tr>
<td>Female</td>
<td>256,490</td>
<td>273,340</td>
<td>292,310</td>
<td>321,880</td>
</tr>
<tr>
<td>TOTAL</td>
<td>877,360</td>
<td>908,830</td>
<td>943,350</td>
<td>999,860</td>
</tr>
</tbody>
</table>

First Alternative

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>677,400</td>
<td>768,890</td>
<td>798,970</td>
<td>845,980</td>
</tr>
<tr>
<td>Female</td>
<td>273,020</td>
<td>311,940</td>
<td>340,810</td>
<td>382,280</td>
</tr>
<tr>
<td>TOTAL</td>
<td>950,420</td>
<td>1,080,830</td>
<td>1,139,780</td>
<td>1,228,260</td>
</tr>
</tbody>
</table>

Second Alternative

(Source: Central Statistical Department)

As has been said before, there are no available figures with regard to the nationality distribution among the population. The following table, however, showing nationality distribution among the population by registered birth in the U.A.E. should permit us to draw some "unofficial" conclusions about the foreign/indigenous ratio.
Table I.2: Registered Births in the U.A.E. by Nationality and Sex, 1978-1979

<table>
<thead>
<tr>
<th>Nationality</th>
<th>No. of Births 1978</th>
<th></th>
<th>No. of Births 1979</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Total</td>
<td>Male</td>
</tr>
<tr>
<td>U.A.E.</td>
<td>5,681</td>
<td>5,472</td>
<td>11,153</td>
<td>6,534</td>
</tr>
<tr>
<td>Other Gulf countries</td>
<td>1,264</td>
<td>1,199</td>
<td>2,463</td>
<td>1,581</td>
</tr>
<tr>
<td>Other Arab countries</td>
<td>2,348</td>
<td>2,156</td>
<td>4,504</td>
<td>3,022</td>
</tr>
<tr>
<td>Non-Arab African countries</td>
<td>46</td>
<td>39</td>
<td>85</td>
<td>44</td>
</tr>
<tr>
<td>Non-Arab Asian countries</td>
<td>4,110</td>
<td>3,991</td>
<td>8,101</td>
<td>4,843</td>
</tr>
<tr>
<td>European countries</td>
<td>108</td>
<td>95</td>
<td>203</td>
<td>155</td>
</tr>
<tr>
<td>American countries</td>
<td>12</td>
<td>13</td>
<td>25</td>
<td>14</td>
</tr>
<tr>
<td>Not stated</td>
<td>61</td>
<td>78</td>
<td>139</td>
<td>135</td>
</tr>
<tr>
<td>TOTAL</td>
<td>13,630</td>
<td>13,043</td>
<td>26,673</td>
<td>16,328</td>
</tr>
<tr>
<td>U.A.E. Total</td>
<td>5,681</td>
<td>5,472</td>
<td>11,153</td>
<td>6,534</td>
</tr>
<tr>
<td>Other countries total</td>
<td>7,949</td>
<td>7,571</td>
<td>15,520</td>
<td>9,794</td>
</tr>
</tbody>
</table>

(Source: Central Statistical Department)

Finally, it should be noted that most of the population is concentrated in the seven capitals. As for the total of 336 villages: only six have more than 2,000 inhabitants; 42 between 500 and 1,999 inhabitants; 54 between 200 and 499; 90 between 50 and 199; and 144 villages have less than 50 inhabitants.
d) **Industry**

**Oil**

The oil industry is the main, if not the only, source of revenue in the U.A.E. at present. Oil represented:

- 98% of total exports in 1974
- 97.8% " " " 1975
- 96.4% " " " 1976
- 95% " " " 1977
- 90% " " " 1978

[The slight decrease in percentages of oil exports is primarily due to government actions to develop non-oil-related industry, in order to avoid a mono-product situation. This topic will be discussed in the following paragraphs.]

In 1979 oil production reached an average of 1.83 million barrels per day, for a revenue of U.S. $12.5 billion. In 1980, production cuts were ordered by the government as part of its policy for "preserving this exhaustible resource for the benefit of future generations," and oil production was cut down to a daily average of 1.7 million barrels. Nevertheless, due to price increases on the international market, revenues for oil exports rose to $18.5 billion in 1980. This enables the U.A.E. to hold an overall external account surplus of $2.5 billion in 1979 ($5 billion in 1980), and World Bank figures state a per capita income of $15,020 in 1980. The gross national product in 1979 was around $14.9 billion and the rate of growth in GNP for 1980 was estimated at about 21.6%. Most of the oil produced is exported. The 1979 figures show that out of a total production
of crude oil (1979) of 668,017 thousand barrels, 659,106 thousand barrels were exported. On a daily average basis, out of 1,830.2 thousand barrels (per day) of average crude oil production in 1979, 1,805.8 thousand barrels (per day) were exported.

The following table shows the main countries importing oil from the U.A.E. in 1979:

<table>
<thead>
<tr>
<th>Country</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>163,560*</td>
</tr>
<tr>
<td>U.S.A.</td>
<td>64,908</td>
</tr>
<tr>
<td>France</td>
<td>55,678</td>
</tr>
<tr>
<td>Netherlands-Intex</td>
<td>52,465</td>
</tr>
<tr>
<td>Holland</td>
<td>38,404</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>8,082</td>
</tr>
</tbody>
</table>

(*Figures are in thousands of barrels)
(Source: Ministry of Petroleum and Mineral Resources)

Local consumption is in the form of refined fuels, divided as follows:

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premium gasoline</td>
<td>87,109*</td>
</tr>
<tr>
<td>Regular gasoline</td>
<td>62,891</td>
</tr>
<tr>
<td>Gas oil</td>
<td>408,432</td>
</tr>
<tr>
<td>Kerosene</td>
<td>6,233</td>
</tr>
<tr>
<td>Aviation gasoline</td>
<td>295</td>
</tr>
<tr>
<td>Aviation kerosene</td>
<td>115,068</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>89,376</td>
</tr>
<tr>
<td>Lubricants</td>
<td>2,268</td>
</tr>
</tbody>
</table>

(*Figures are in thousands of imperial gallons)
(Source: Ministry of Petroleum and Mineral Resources)

Most of the refined fuel is produced in the refinery of Umm al-Nar in the emirate of Abu-Dhabi. The capacity of this refinery was 15,000 barrels/day in 1980. In addition, the Ruwais refinery, due to come into operation in late 1981, will have an initial capacity of 120,000 barrels/day. In late 1980, a contract was awarded for the extension of Umm al-Nar refinery, in order to increase the capacity from 15,000 to 80,000 barrels/day by 1983. This will enable the U.A.E. to become fully self-sufficient in refined fuels.
Finally, to conclude the oil chapter, it should be noted that the main production of oil is in the emirate of Abu Dhabi. Dubai comes next, with 20% of total production. Other emirates have seen fairly recent discoveries, with a promising production potential, yet to be developed.

Gas

Another source of income has been the gas industry, where Abu Dhabi's reserves alone are now among the largest in the world. Previously, all of the offshore-associated gas reserves were flared off, until the opening in 1977 of the Abu-Dhabi Gas Liquefaction Company (ADGLC) on Das Island. Flaring was reduced from 79% in 1976 to 58% in 1979, for a production in the ADGLC plant of 1,982.4 thousand metric tons in 1979. An onshore collecting scheme was put forward with the creation of the Abu-Dhabi Gas Industries Limited (GASCO), due to start in late 1981. This system will link several onshore fields with a fractionation plant at Ruwais for a total production capacity of 3 million tons of liquefied petroleum gas (LPG), 2.4 millions tons of gas-oil, 1.57 million tons of propane, and 1.92 million tons of butane.

Dubai also has its share of gas production. A liquefaction plant at Jebel Ali for the Dubai Gas Company (DUGAS) was constructed. But the future development of this plant required more than the available gas output, and an agreement was reached on a gas pipeline that will link DUGAS with Abu Dhabi's onshore collecting network. However, a major gas field was discovered on offshore Dubai, and the feasibility of this new field is under study.
Non oil-related industries

As has been said before, many government actions have been taken in the direction of diversifying the sources of national income, namely developing industries other than oil-related ones. These actions have been on different levels: the government would act as the main investor in some cases, especially in heavy industry; in other cases, incentives would be given to smaller investors, e.g., in the form of land allocation or trade facilities. This latter is usually the case for light industry. Thus the country could be divided into three major parts of industrial development: the emirate of Dubai, the emirate of Abu Dhabi, and the northern emirates.

Dubai, in spite of some important oil reserves, has always been known as the center for mercantile activities in the Gulf, and within that scope, several industrial projects have been promoted, the most important of which is the Jebel Ali complex. The main idea behind Jebel Ali was to create an industrial community where the different projects would be linked in terms of production and services. In 1976, the decision was taken to create a deep sea port and dry docks facilities. In 1981, the port had over 15km of quays and wharfs in operation.

The other major plant is the DUBAL plant for aluminum smelting, with an installed capacity of 135,000 tons of aluminum ingots a year. The DUBAL company is 80% owned by the government and was built in 1979, at a cost of about $800 million. At the moment, though, DUBAL's production remains entirely geared towards export. This plant is powered by gas turbines driven by fuel from the neighboring DUGAS plant (see Gas section). DUBAL has its own desalination plant, one of the largest in the world with a production of 25 million gallons a day. The surplus, some 20 million gallons a day, is being piped into the city of Dubai for local use.
Another major industrial plant is DUCAB, a heavy-duty cable manufacturer opened in 1979. This plant is also largely owned by the government and supplies heavy-duty cable for the local market and export.

Several other lighter industries are situated in the port industrial area, such as a steel manufacturer and an aluminum fabricator, a company which at the moment is still importing its raw material which is, however, soon to be replaced by metal from DUBAL. In the industrial zone between the city of Dubai and Jebel Ali, one can find a number of small scale industries, mainly food plants and a ballpoint pen factory.

The emirate of Abu Dhabi has also a number of plants, namely a steel rolling mill, a paper bag factory, a brick works factory, a concrete block factory, a fiberglass and plastic pipes factory, a compost plant, a plant for animal feed production, a fertilizer factory, and some food products factories.

In the northern emirates, the lead was taken by the emirate of Ras al-Khaimah. In 1980, the first explosives factory in the Gulf started production, and in 1981 a pharmaceutical factor was due to open. Also manufacture of aggregates using the rocks of the Hajar (stone) mountain provides a major supply for the other emirates, and even reaches markets in Saudi Arabia and Kuwait.

The other emirates, although basing their economy on agriculture and tourism, have tried to establish an industrial base. Fujaîrah has begun the construction of a ceramic tile factory, a cement factory, and an asbestos plant. A marble factory is already open and has started production. An asbestos and cement factory has also been opened in the emirate of Um al-Qaiwan.

Finally, it shall be noted that there was a tendency on the part of
investors to duplicate existing industries that showed some success. This created a production in excess of the country's needs, as was the case with the five cement factories. Therefore, an instance was created in 1979: the General Industrial Corporation (GIC) in Abu Dhabi, which was given the power to "prevent the establishment of any new industry that would have a serious effect on existing production." (The GIC was also set up "to supervise all industrial developments and issue licenses, along with providing advice and assistance to local businessmen in carrying out feasibility and marketing studies.")

e) Labor

The labor situation in the U.A.E. is interesting and more or less typical of all the new states in the Gulf. Unemployment is practically nonexistent, in the sense that it constitutes 2.08% of the labor force, and the unemployment force is largely made up of newly arrived workers who have never worked in the U.A.E. before. (The 1975 figures show that out of 6,186 unemployed, 3,990 have never worked in the U.A.E. before.) Another feature of the labor force is that it is mainly made up of foreign workers. Again, it is difficult to back up this statement with official figures, which are unavailable, but an attempt will be made later in the chapter to give some figures that could provide a general idea on the subject.

The 1975 census figures show that for a population of 437,708 (10 years of age and older), 290,330 were employed and 6,186 were unemployed, for a total labor force of 296,516 (9,961 female, 286,555 male). On the other hand, the non-labor force comprised 76,624 home-makers; 44,436 students; 4,319 unwilling to work; 14,820 unable to work; and 993 not stated.
The following chart represents the proportions:

Figure I.3: Population (10 years and older) in Relation to the Labor Force

(Source: Central Statistical Department)

As for employment status, we see that in 1975, 1.72% of the economically active population (10 years and older) were employers, 7.3% were own-account workers, and 89.3% were employees.
Table I.4: Economically Active Population (10 years and older) by Employment Status and Sex - 1975

<table>
<thead>
<tr>
<th>Status</th>
<th>Total</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employer</td>
<td>5,114</td>
<td>48</td>
<td>5,066</td>
</tr>
<tr>
<td>Own-account worker</td>
<td>21,710</td>
<td>196</td>
<td>21,514</td>
</tr>
<tr>
<td>Employee</td>
<td>264,642</td>
<td>9,229</td>
<td>255,413</td>
</tr>
<tr>
<td>Unpaid worker</td>
<td>617</td>
<td>54</td>
<td>563</td>
</tr>
<tr>
<td>Not stated</td>
<td>443</td>
<td>12</td>
<td>431</td>
</tr>
<tr>
<td>Unemployed, never worked in U.A.E. before</td>
<td>3,990</td>
<td>422</td>
<td>3,568</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>296,516</td>
<td>9,961</td>
<td>286,555</td>
</tr>
</tbody>
</table>

(Source: Central Statistical Department)

A large share of the labor force is employed in the building sector. In 1975, 31.5% of the labor force was in building and construction, followed by government services with 21.34%, then wholesale, retail trade and restaurant and hotels with 12.66%. In 1977, although the figures are estimates, the building sector also occupied first place, with 32.39%; however, we see a decline in government service to 14.86% in favor of the wholesale, retail trade, restaurant and hotels sector with 15.39%.
Table I.5: Economically Active Population (10 years and older) by Industry - 1975-1977

<table>
<thead>
<tr>
<th>Industry</th>
<th>Labor Force</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1975</td>
</tr>
<tr>
<td>Agriculture, forestry, hunting, fishing</td>
<td>13,229</td>
</tr>
<tr>
<td>Mining, quarrying, petroleum extraction</td>
<td>6,791</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>17,205</td>
</tr>
<tr>
<td>Electricity, gas, water</td>
<td>6,237</td>
</tr>
<tr>
<td>Building &amp; construction</td>
<td>93,411</td>
</tr>
<tr>
<td>Wholesale &amp; retail trade, restaurants &amp; hotels</td>
<td>37,524</td>
</tr>
<tr>
<td>Transport, storage, communications</td>
<td>23,383</td>
</tr>
<tr>
<td>Financing, insurance, real estate, business services</td>
<td>5,960</td>
</tr>
<tr>
<td>Government services</td>
<td>63,272</td>
</tr>
<tr>
<td>Personal &amp; social services</td>
<td>23,218</td>
</tr>
<tr>
<td>Total employed</td>
<td>290,330</td>
</tr>
<tr>
<td>Unemployed</td>
<td>6,186</td>
</tr>
<tr>
<td>TOTAL LABOR FORCE</td>
<td>296,516</td>
</tr>
</tbody>
</table>

(Source: Central Statistical Department)

It is very hard to define wages, as they vary not only according to the skills and qualifications of an employee, but also according to nationality. (An Indian engineer with certain qualifications is paid less than a European or American engineer holding the same qualifications.) Also, wages may vary between the public and private sectors. Nevertheless, some figures are available on the wages of government employees, with regard to their educational and professional levels. Some statistics are also available on wages by industry in the private sector.
Table I.6: Government Employees' Monthly Salaries by Educational Level and Sex - December 1977

<table>
<thead>
<tr>
<th>Educational level</th>
<th>Illiterate</th>
<th>Primary and prep. school</th>
<th>Secondary school</th>
<th>Below university</th>
<th>University</th>
<th>Above university</th>
<th>Not stated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>No. of employees</td>
<td>Salaries</td>
<td>No. of</td>
<td>Salaries</td>
<td>No. of</td>
<td>Salaries</td>
<td>No. of</td>
</tr>
<tr>
<td>Male</td>
<td>32,277</td>
<td>14,017.6</td>
<td>4,260</td>
<td>2,718.9</td>
<td>7,046</td>
<td>5,212</td>
<td>1,921</td>
</tr>
<tr>
<td>Female</td>
<td>703</td>
<td>214.8</td>
<td>436</td>
<td>215.9</td>
<td>2,258</td>
<td>1,557.7</td>
<td>1,280</td>
</tr>
<tr>
<td>TOTAL</td>
<td>32,980</td>
<td>14,232.4</td>
<td>4,696</td>
<td>2,934.8</td>
<td>9,304</td>
<td>6,769.7</td>
<td>3,201</td>
</tr>
</tbody>
</table>

Average wage: .4315, .6249, .7276, .8602, 1.258, 1.705, .5589

(* Salaries in thousands of U.S. dollars)
(Source: Central Statistical Department)

Fig. I.7: Average Wages* by Educational Level for Government Employees - December 1977

Wages

(* Wages in U.S. dollars)
(Source: Central Statistical Department)

Total employed, male: 52,258 Salary: 31,588.4
Total employed, female: 6,290 Salary: 4,696.1
TOTAL 58,548 36,284.5

25
### Table 1.8: Government Employees and Monthly Salaries by Occupation and Sex - December 1977

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Administrative</th>
<th>Profess./Tech.</th>
<th>Sales workers</th>
<th>Clerical</th>
<th>Production</th>
<th>Service</th>
<th>Agricultural</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of employees</td>
<td>No. of empl.</td>
<td>Salary</td>
<td>No. of employees</td>
<td>No. of empl.</td>
<td>Salary</td>
<td>No. of employees</td>
</tr>
<tr>
<td>Male</td>
<td>584</td>
<td>1,126.9</td>
<td>5,369</td>
<td>5,760</td>
<td>60</td>
<td>63.5</td>
<td>3,788</td>
</tr>
<tr>
<td>Female</td>
<td>8</td>
<td>11.8</td>
<td>2,209</td>
<td>1,913.5</td>
<td>1</td>
<td>.5</td>
<td>708</td>
</tr>
<tr>
<td>TOTAL</td>
<td>592</td>
<td>1,138.7</td>
<td>7,578</td>
<td>7,673.5</td>
<td>61</td>
<td>64</td>
<td>4,596</td>
</tr>
<tr>
<td>Average wage</td>
<td>1.923</td>
<td>1.012</td>
<td>1.049</td>
<td>.7159</td>
<td>.5746</td>
<td>.4090</td>
<td>.3018</td>
</tr>
</tbody>
</table>

(* Salaries in thousands of U.S. dollars)
(Source: Central Statistical Department)

### Table 1.9: Establishments (4 employees or more), Employees, and Total of Monthly Salaries by Industry - October 1979

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, forestry, hunting, fishing</td>
<td>17</td>
<td>305</td>
<td>153,460</td>
<td>67,658</td>
<td>.5031</td>
<td>222</td>
</tr>
<tr>
<td>Mining, quarrying, petroleum extraction</td>
<td>54</td>
<td>4,856</td>
<td>4,048.058</td>
<td>983,685</td>
<td>.8336</td>
<td>203</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>1,312</td>
<td>24,989</td>
<td>11,084.130</td>
<td>6,129.359</td>
<td>.4435</td>
<td>245</td>
</tr>
<tr>
<td>Building &amp; construction</td>
<td>730</td>
<td>86,805</td>
<td>41,539.425</td>
<td>23,042,486</td>
<td>.4785</td>
<td>265</td>
</tr>
<tr>
<td>Wholesale &amp; retail, restaurants &amp; hotels</td>
<td>3,058</td>
<td>40,974</td>
<td>17,286.503</td>
<td>9,957.251</td>
<td>.4218</td>
<td>234</td>
</tr>
<tr>
<td>Transport, storage, communications</td>
<td>303</td>
<td>10,481</td>
<td>6,161.113</td>
<td>2,283,207</td>
<td>.5878</td>
<td>218</td>
</tr>
<tr>
<td>Financing, insurance, real estate, business</td>
<td>531</td>
<td>11,534</td>
<td>10,248.601</td>
<td>2,316,120</td>
<td>.8885</td>
<td>200</td>
</tr>
<tr>
<td>Community, social &amp; personal services</td>
<td>726</td>
<td>9,514</td>
<td>4,280.878</td>
<td>2,179,558</td>
<td>.4499</td>
<td>226</td>
</tr>
<tr>
<td>TOTAL</td>
<td>6,731</td>
<td>189,559</td>
<td>94,802.168</td>
<td>46,959,324</td>
<td>.5001</td>
<td>248</td>
</tr>
</tbody>
</table>

(* Salaries in thousands of U.S. dollars)
(Source: Central Statistical Department)
It is extremely difficult to determine the exact composition of the labor force in terms of nationalities. The only available statistics are those of the work permits issued yearly by nationality, along with work permit cancellations for the respective years. Unofficial figures, though, account for at least 90% of foreign workers for the total labor force in the U.A.E. The table below shows that for the years 1975-1976 alone, 342,641 work permits were issued (including cancellations). This represents almost 180% of the increase in the labor force between 1975 and 1977—that is, 188,634 workers. (There was a total labor force of 296,516 for 1975 and 485,150 for 1977.) These figures seem extremely inexact. This is due to the fact that it is not known how many of the workers have actually come to the country after having obtained work permits. (The work permit is issued before entry to the country is granted.) Nevertheless, it is clear that foreign workers heavily dominate the labor force.

Table I.10: Work Permits Issued and Cancelled, 1975-1979

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Issued</td>
<td>127,938</td>
<td>239,555</td>
<td>226,509</td>
<td>164,401</td>
<td>120,109</td>
</tr>
<tr>
<td>Cancelled</td>
<td>7,233</td>
<td>17,619</td>
<td>41,359</td>
<td>67,468</td>
<td>78,091</td>
</tr>
<tr>
<td>TOTAL</td>
<td>120,705</td>
<td>221,936</td>
<td>185,150</td>
<td>96,933</td>
<td>42,018</td>
</tr>
</tbody>
</table>

(Source: Ministry of Labor and Social Affairs)

As for foreign workers' distribution by nationality, India takes the lead with 42.6% of the work permits issued in 1977, 36.7% in 1978, and 45.8% in 1979. Pakistan follows, with 23.4% in 1977, 22.1% in 1978, and 20.9% in 1979. The Arab countries come in third, with 17.8% in 1977, 15.6% in 1978, and 12.2%
in 1979. The following chart shows the distribution of work permits by nationality in 1979:

Figure I.11: Work Permits by Nationality Groups - 1979

(Source: Ministry of Labor and Social Affairs)

f) Transport and communications

In the field of transport and communications, the emirates have achieved impressive results. From a few scattered, small fishing and trade ports, a very small airport and one partly paved road in existence some 20 years ago, the country presently boasts of four major ports with 170 deep-water berths (about half the berths of the entire Arabian Gulf), four major airports handling a passenger flow of almost 2 million a year (981,847 arrivals; 935,405 departures; 46,258 transit in 1979), along with a cargo handling total of 80,000 tons in 1979. Two new airports are being built as of 1981. As for the new road system, although there are no figures on total length of the network, one can say that it connects almost every part of the country
with the cities and all economic centers. Practically all of the roads are now paved, and vary in width between six and eleven meters. In other words, there are practically no constraints on heavy road transportation.

The telecommunications network is equally densely developed and has reached a high level of efficiency, both on local and international levels.

g) Building and construction

The building sector in the U.A.E. is very developed and important in the sense that it employs the largest share of the labor force -- 32.39% (1979 figures; see page 23). While it has mainly focused on housing, the last three years have witnessed an increase in industrial building projects (i.e., buildings intended for industry but not industrialized buildings). This is due mainly to two reasons. The first, discussed earlier, is the government's desire to develop industries other than oil, in order to diversify the economy. The second is the 1977 recession, where the country experienced a decrease in the rate of economic growth. Since virtually all of the country's requirements are imported, inflation was also imported, and reached an annual level of around 30% in 1977. The central monetary authority, the Currency Board, had to take stiff measures to ensure stability. This led to the closing of several banks and, more important, to the cutting down of loans to investors. The result was a dramatic slow-down in the private building sector and real estate development. Nevertheless, the country's economy picked up around two years later, and has been witnessing a steady, if less dramatic, growth since. On the other hand, government expenditure in the building sector remained almost unchanged, and amounted to around $115.6 million for the year 1979.

The 1975 census numbers a total of 75,504 buildings (built structures) in the major cities of the U.A.E. These buildings are divided by type as
Concrete is the main structural material used in these buildings, largely in the form of concrete blocks (68% of total buildings) or as reinforced concrete (11.5%).

Table I.12: Distribution of Cities' Buildings by Type of Building and Main Structural Material - 1975

<table>
<thead>
<tr>
<th>Type</th>
<th>Reinforced concrete</th>
<th>Concrete brick</th>
<th>Timber</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Villa</td>
<td>5,305</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>5,305</td>
</tr>
<tr>
<td>Building</td>
<td>1,155</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>1,155</td>
</tr>
<tr>
<td>House</td>
<td>2,218</td>
<td>46,252</td>
<td>2,798</td>
<td>---</td>
<td>51,268</td>
</tr>
<tr>
<td>Other</td>
<td>---</td>
<td>5,302</td>
<td>6,053</td>
<td>6,421</td>
<td>17,776</td>
</tr>
<tr>
<td>TOTAL</td>
<td>8,678</td>
<td>51,554</td>
<td>8,851</td>
<td>6,421</td>
<td>75,504</td>
</tr>
</tbody>
</table>

The great majority of these buildings (97%) are one story high. This is very understandable, considering that, on the one hand, land has never created a real problem in terms of areas allocated to urban development, and soil characteristics are more or less the same in any given area of development. On the other hand, the construction of high- to medium-rise buildings necessitates...
special foundation structures (in most cases piling techniques are used), which are extremely costly. These conditions, favorable to the horizontal expansion of the cities, resulted in the above-mentioned high percentage of one-story houses. In 1975, the distribution of buildings in cities by number of floors stood as follows:

Table I.13

<table>
<thead>
<tr>
<th>Type</th>
<th>1 floor</th>
<th>2 floors</th>
<th>3 floors</th>
<th>4 floors</th>
<th>5 floors</th>
<th>6+ floors</th>
<th>Not stated</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Villa</td>
<td>4,161</td>
<td>994</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>201</td>
<td>5,305</td>
</tr>
<tr>
<td>Building</td>
<td>---</td>
<td>---</td>
<td>482</td>
<td>236</td>
<td>95</td>
<td>138</td>
<td>153</td>
<td>1,155</td>
</tr>
<tr>
<td>House</td>
<td>51,268</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>51,268</td>
</tr>
<tr>
<td>Other</td>
<td>17,776</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>17,776</td>
</tr>
<tr>
<td>TOTAL</td>
<td>73,205</td>
<td>994</td>
<td>482</td>
<td>236</td>
<td>95</td>
<td>138</td>
<td>354</td>
<td>75,504</td>
</tr>
</tbody>
</table>

(Source: Central Statistical Department)

It should be noted that these figures are only valid for cities and urban areas.

While the cities' public infrastructure is handled by the government, the building sector, by and large, and more specifically the housing sector is left to private investors. The rural areas, however, are to a great extent the public sector's domain. Projects consist mainly of replacing the old village housing stock by new housing compounds. This represents the government's will to "provide better standards for the population," but it should be kept in mind that the inhabitants themselves view the new houses as a sign of progress and wealth and enables them to feel included in the "modernization of the state." This trend is clear when one looks at the number of applications for housing. Until the end of 1979, 11,394 applications for public
housing were submitted; 4,055 houses were completed, out of which 3,611 were actually distributed. It should be noted here that houses in the public sector are granted free to applicants if eligible.

As seen earlier, most of the villages have no more than 50 inhabitants (see Population section), therefore the public housing projects are very scattered and hardly exceed 50 units at a time.

By comparison to low-cost housing in other developing countries, it may be said that public housing in the U.A.E. is of very high standards, as shown in the following table:

Fig. I.14: Applications for Public Housing, Units Completed and Distributed - End of 1979

(Source: Ministry of Public Works and Housing)
Table I.15: Low-Cost Housing Executed During 1977-1979

<table>
<thead>
<tr>
<th>Year</th>
<th>No.</th>
<th>No. of rooms*</th>
<th>Area m²</th>
<th>Cost**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>1,377</td>
<td>4,332</td>
<td>123,535</td>
<td>28,849</td>
</tr>
<tr>
<td>1978</td>
<td>525</td>
<td>1,575</td>
<td>46,095</td>
<td>11,240</td>
</tr>
<tr>
<td>1979</td>
<td>295</td>
<td>1,260</td>
<td>37,211</td>
<td>6,785</td>
</tr>
</tbody>
</table>

(* Rooms include bedrooms, dining room, majlis and hall; it does not include bathrooms and kitchen)

(** Cost is based on tender values, in thousands of U.S. dollars)

(Source: Ministry of Public Works and Housing)

Characteristics of the average low-cost house are shown in the table below:

Table I.16: Average Low-Cost House - 1977-1979

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of rooms</th>
<th>Area m²</th>
<th>Cost*</th>
<th>Cost/m²**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>3.1</td>
<td>89.7</td>
<td>20.9</td>
<td>233</td>
</tr>
<tr>
<td>1978</td>
<td>3.0</td>
<td>87.8</td>
<td>21.4</td>
<td>243</td>
</tr>
<tr>
<td>1979</td>
<td>4.27</td>
<td>126.1</td>
<td>23</td>
<td>182</td>
</tr>
</tbody>
</table>

(* in thousands of U.S. dollars)

(** in U.S. dollars)

(Source: Ministry of Public Works and Housing)

The main point of interest here is the fact that although between the years 1978 and 1979 one can witness an on-the-average increase of 43.8% in the area allocated to public housing, a decrease of about 33.5% in the cost per square meter has been realized. This is mainly due to two factors. The first one could be seen as the aftermath of the 1977 recession (see page 29). At the end of 1977, the building sector witnessed a slow-down. This created a
surplus of labor on the market, which in turn led to a drop in the wages of both skilled and unskilled labor. Between 1977 and 1978, the average wages for skilled labor dropped by 58% and picked up only by 17% in 1979. This factor contributed to the drop in overall construction costs during that period.

Table I.17: Average Daily Wages of Workers and the Cost Per M$^2$ of Public Buildings - 1973-1979

<table>
<thead>
<tr>
<th>Year</th>
<th>Unskilled labor</th>
<th>Skilled labor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>4.35</td>
<td>8.97</td>
</tr>
<tr>
<td>1974</td>
<td>6.41</td>
<td>12.82</td>
</tr>
<tr>
<td>1975</td>
<td>7.69</td>
<td>15.38</td>
</tr>
<tr>
<td>1976</td>
<td>8.97</td>
<td>16.66</td>
</tr>
<tr>
<td>1977</td>
<td>8.97</td>
<td>17.94</td>
</tr>
<tr>
<td>1978</td>
<td>7.1</td>
<td>12.82</td>
</tr>
<tr>
<td>1979</td>
<td>8.7</td>
<td>14.35</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Cost/m$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>200.0</td>
</tr>
<tr>
<td>1974</td>
<td>230.7</td>
</tr>
<tr>
<td>1975</td>
<td>256.4</td>
</tr>
<tr>
<td>1976</td>
<td>307.6</td>
</tr>
<tr>
<td>1977</td>
<td>220.5</td>
</tr>
<tr>
<td>1978</td>
<td>208.9</td>
</tr>
<tr>
<td>1979</td>
<td>221.2</td>
</tr>
</tbody>
</table>

(* Base year 1973)
(** Figures in U.S. dollars)
(Source: Ministry of Public Works and Housing)
The second factor is mainly related to the building industry as such. Many construction-related industries were established, including five cement factories, a steel-rolling mill, several concrete block factories, a P.V.C. pipes factory, several aluminum assembly plants producing all types of windows, doors and door frames, some paint factories, and other smaller facilities. The quality of production was kept at a very high level and resulted in a reduction of the construction sector's dependency on imports, thus contributing to the reduction of construction costs. To conclude this section, a plan is included below, which could be considered as typical of a public-sector house, in the sense that most of these layouts include the following features:

-- all functions evolve around a circulation or entrance hall
-- all houses are fenced
-- all houses have a back yard and often a front yard as well
-- all houses are single-unit, one-story detached houses.

Evidently, variations derived from this "theme" may be found. These variations occur in size of rooms, number of rooms, orientation, etc.

Fig. I.19: Two-Bedroom Public House (not drawn to scale)
h) Conclusion and Assessment

Before going any further, it should be remembered that it is not the primary purpose of this study to give a very detailed and thorough survey of the U.A.E. Some information was consciously left out, as it was not seen as relevant to the scope of this work. This includes agriculture, fishing, health, leisure and tourism, etc. Information regarding these fields may be found in the literature on the U.A.E., referred to in the bibliography.

The situation in the U.A.E., as revealed in the description in the preceding chapter, is very unique, though characteristic of the whole Gulf area. The U.A.E. has moved, in less than a decade, from an underdevelopment stage of economic development to the level of developed countries. The discovery of oil, along with the energy crisis in the industrialized countries, has created a sudden wealth. This wealth has reached such a level that one might see no constraints capable of hindering the country's development.

Generally, in both underdeveloped and developing countries, there are certain generic constraints, which act as governors of policies. This may be assumed to be equally true for the specific field of industrialized building. The idea of building systems emanated in Europe from a crisis engendered by World War II. Cities had to be rebuilt, at the least expense and in the shortest time possible. Nowadays, building systems are used in developing countries to answer the same needs, even though the nature of the crises might differ.

In the U.A.E., however, the situation is different. There is indeed a housing shortage in the public sector, but this shortage is accompanied by several important factors:
The government is allocating ample and large funds to the public housing sector.

Public housing is allocated only to citizens of the U.A.E.

The number of houses needed is "relatively" small (if every application for a public house submitted represented the need of one individual, the shortage ratio to the population would be of 1.1%).

Public housing is regarded as a very temporary step by the inhabitants, who, on the average, move out after two years.

There is a saturation, or even a surplus, of housing in the private sector.

These conditions, obviously, are not sufficient to justify reverting to building systems as the answer to the housing shortage. On the other hand, there is a very defined government policy for industrializing the country, as oil is considered to be a relatively temporary source of revenue, and since the other natural resources of the country are limited, industry is regarded as the alternative source of national income for the future. It is justly thought that the local market, although highly dependent on imports, will soon reach a state of saturation and stability, and will not be able to absorb production from industrialization on a national scale.

Based on these considerations, it is the considered opinion of the author that building systems should not be considered as the solution to a problem, but as an industry geared essentially towards exports. This would not only, as an inevitable but necessary first step, answer the contingencies of the present housing need, but would also act within the framework of the industrialization policy for the future.

The following chapters are an attempt to confirm the validity of this assumption. This will be done by:

-- accepting the overall goal of developing industrialized building as primarily an export industry, and
-- developing a set of valid objectives to be weighed against a selected range of industrialized building system types.

A first step will be the description of the method to be used, the second step being its implementation.

The concluding chapter will review the consequences of the choice of a given industrialized building system type, by outlining specific industrialized building product choices, in terms of their performance, compatibility, range, type, etc., and their potential utility as export items in the region's external market.
II- The Methods
Recent decades have seen the emergence of numerous and various building systems, all of which try to systemize the design, planning, and production processes of the building industry. Fundamental and less fundamental differences exist among these various systems. These differences are mainly due to the fact that the systems, in having to deal with optimizing their effectiveness with regard to considerations such as cost, time, risk, techniques, etc., will tend to put the emphasis on one of those aspects, at the expense of the others. There is no one system capable of producing a solution to all of the problems, not to mention the different political, environmental, climatical contexts in which the system is to be implemented. Therefore, the decision-making process is one of defining the objectives the system has to achieve, in relation with the context -- defining the priorities among these objectives, then evaluating the capabilities of the system to respond to the various objectives.

Fount T. Smothers (DMG-DRS Journal, Vol. 9, no. 2, April-June 1975) summarizes the decision-making process as requiring three basic components:

"1. A value component: A process to articulate:
   a) The decision-maker's objectives for the organizational structure (system).
   b) The priorities and relative values attached to each of these objectives by the decision-maker.

2. A performance component: A process to predict the inherent capabilities of the alternative structures to successfully respond to each of the decision-maker's objectives

3. A decision component: A process to select the organizational structure whose performance profile most clearly matches the decision-maker's objective profile."

As we agree that the decision-making process is a very subjective process, it goes without saying that the objectives to be reached are very specific to the context of the project and to the decision-maker's requirements. The
difficulty lies more in the definition of priorities; in other words, of all the objectives, which is the most important? which less important? Although in some cases the difference in the relative importance of some objectives is obvious, in more cases it is difficult to define and evaluate the differences. We come here to the problem of "weighting" or "ranking" of objectives. Many methodologists, namely Ackoff (1968), Bross (1965), Churchman (1961), Raiffa (1968), Rittel (1972) among others, have worked on the subject. Several methods for weighting objectives were developed. For the purpose of this study we will retain two methods:

-- "The method of paired comparisons" -- an old technique attributed to an early psycho-physicist by the name of Fechner (1860)

-- "The Churchman-Ackoff method for weighting objectives."

The choice of these methods is based on the fact that they seem to be accurate enough in helping define and weight the relative importance and value of objectives. Both these methods will be described in the following chapters. For the decision-making process, we will use "the Alpha-Beta (α-β) method for decision-making with multiple objectives" (D.P. Grant, DMS-DRS Journal, Vol. 9, no. 2, April-June, 1975) (Churchman, Ackoff and Arnoff, Introduction to Operations Research, 1957).

a) The Alpha-Beta Method

Before going any further in the description of the method, it would be useful to define some of the terms and concepts that will be used. If it is agreed that an objective is a specific aim that has a means of measuring the degree to which it is achieved, as opposed to a goal, which is a general statement of aims, then a weight is a number assigned to an objective
indicating its judged relative importance among other objectives (D.P. Grant, 1976). A **nominal scale** is a scale of classification that gives names or class, as for an **ordinal scale** not only classifies and gives names but also gives order or rank. Therefore, **ranking** is transforming from a nominal scale into an ordinal scale. **Weighting** is transforming an ordinal classification into a **difference or interval scale**.

The Alpha-Beta model is "a judgment of weighted desirability" (Grant, 1976). It is the process that combines the value component and performance component mentioned earlier. In other words, judgments are made about the relative suitability of a given proposal in meeting the objectives that are weighted according to their relative importance. If such judgments are made for several proposals, then the aggregate results should determine which of these proposals is the more suitable to the decision-maker's needs.

Alpha values are judgments about the weights of relative importance of objectives. The decision-maker, after setting his objectives, would want to state his priorities among these objectives, and therefore would "weight" the relative importance of the objectives. The number attributed to each objective (weight) will reflect the difference in importance between them. If we have four (4) objectives, and the second objective is found to be twice as important as the first one, half as important as the third, and one-third as important as the fourth, then the following table would obtain:

<table>
<thead>
<tr>
<th>Objective</th>
<th>Weight</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective 1</td>
<td>0₁</td>
<td>1</td>
</tr>
<tr>
<td>Objective 2</td>
<td>0₂</td>
<td>2</td>
</tr>
<tr>
<td>Objective 3</td>
<td>0₃</td>
<td>4</td>
</tr>
<tr>
<td>Objective 4</td>
<td>0₄</td>
<td>6</td>
</tr>
</tbody>
</table>

These "weights" are on an arbitrary scale, and the decision-maker may want
to set his own priority scale, with an assigned number per degree of impor-
tance. (An example: very important = 10; important = 8; indifferent = 5;  
not important = 1.) Another scale is suggested, and it is one where the  
sum of those numbers, or Alpha values, is set to be equal to a set number  
(1.00 or 10.00 or 100.00). It is thought that this may force the decision-
maker to operate on a "trade-off" basis in determining the importance of his  
objectives. The table then becomes:

<table>
<thead>
<tr>
<th>0₁</th>
<th>1</th>
<th>or 7.7 or .77 etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0₂</td>
<td>2</td>
<td>15.4 1.54</td>
</tr>
<tr>
<td>0₃</td>
<td>4</td>
<td>30.8 3.08</td>
</tr>
<tr>
<td>0₄</td>
<td>6</td>
<td>46.2 4.62</td>
</tr>
</tbody>
</table>

As was said before, judgments about the relative importance of objectives are  
not always made, and later in the chapter we will propose and describe two  
methods for that purpose: the Churchman-Ackoff method and the method of  
paired comparison for weighting objectives.

Beta values are judgments about the relative desirability or preference or suitability of a proposal for the objectives set. For every proposal, a question is asked in relation to each objective: How desirable, or preferred, or suitable is the proposal to that objective? The scale for judgments is a pre-set one, and the decision-maker might want to choose one among the most used scales, i.e., -5 → 5, 1 → 9, or 0 → 4. On a scale of 1 → 9, we would have 9 most desirable, 8-7-6 desirable, 5 neutral, 4-3-2 undesirable, and 1 most undesirable (or preferred or suitable).

Having determined the Alpha values of our objectives and the Beta values for the proposal with regard to every objective, the product Alpha value x Beta value will give us a judgment on the desirability of the proposal (or system) in relation to the objectives and their judged importance. And
by summing up the Alpha-Beta product we will have an overall judgment for
the proposal. In comparing several proposals, the one with the highest
sum of Alpha-Beta products ranks first, the second-highest second, and so on.
The following tabular format for the Alpha-Beta model is quite explicit

Fig. II.1: Alpha-Beta Table for Proposal X (Beta value scale: 1 = most
undesirable, 9 = most desirable)

<table>
<thead>
<tr>
<th>List of objectives</th>
<th>Beta values for X with respect to each objective</th>
<th>Alpha values for each objective</th>
<th>Alpha-Beta product</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>Beta (x,1) =</td>
<td>Alpha-1 =</td>
<td>Beta(x,1) x Alpha-1 =</td>
</tr>
<tr>
<td>0-2</td>
<td>Beta (x,2) =</td>
<td>Alpha-2 =</td>
<td>Beta(x,2) x Alpha-2 =</td>
</tr>
<tr>
<td>0-3</td>
<td>Beta (x,3) =</td>
<td>Alpha-3 =</td>
<td>Beta(x,3) x Alpha-3 =</td>
</tr>
</tbody>
</table>

Although the sum of the Alpha-Beta products is the overall judgment, the fact
of dividing it by the sum of Alpha's will enable us to read the judgement on
the Beta scale.

To summarize, we will go over the procedure, then give an example of
how to use it:

Step 1 -- Determine the objectives.
Step 2 -- Choose the systems to be evaluated.
Step 3 -- Decide upon a scale for Beta-values.
Step 4 -- Construct a table for each system.
Step 5 -- Give Beta-values for every system with respect to
each objective.
Step 6 -- Give Alpha values (an objective weighting method
might be used here and the results normalized on a
standard sum).
Step 7 -- Decide upon an aggregation function to be used.
Step 8 -- Aggregate Alpha and Beta value judgments.
Step 9 -- Derive overall judgment about each system.
Step 10 -- Compare the overall judgments for all the
systems and rank them.
To illustrate this procedure, we will take the example of a low-cost housing project (it is a very simple example with several assumptions):

Step 1: Let us assume that the objectives are:

- $O_1$: ease of assembly
- $O_2$: short erection time
- $O_3$: use of medium-weight equipment
- $O_4$: production made in situ

Step 2: We will assume that the choice is to be made between a large panel system and a small-components system.

Step 3: The Beta-scale will be $1 \rightarrow 9$, with $9 = \text{most desirable}$, $5 = \text{neutral}$, $1 = \text{most undesirable}$.

Step 4: For ease of readings, the table will be set at the end.

Step 5: In the Beta value judgments, we will say that the large panel system is desirable for ease of assembly ($7$), more desirable for time of erection ($8$), undesirable for the use of medium-weight equipment ($4$), most undesirable for production on site ($1$).

The small components will score ($6$) for ease of assembly, ($6$) for time of erection, ($9$) for use of medium-weight equipment, ($8$) for production on site.

Step 6: Assumptions again will be made for the Alpha values and we will say that the use of medium-weight equipment is twice as important as the time of erection, which in turn is twice as important as ease of assembly, which in turn is three times less important than production on site.

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Alpha value</th>
<th>if we normalize Alpha values so that the sum is equal to 10.00, then</th>
<th>Objectives</th>
<th>Alpha value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$O_1$</td>
<td>2</td>
<td>1.00</td>
<td>$O_1$</td>
<td>1.00</td>
</tr>
<tr>
<td>$O_2$</td>
<td>4</td>
<td>2.00</td>
<td>$O_2$</td>
<td>2.00</td>
</tr>
<tr>
<td>$O_3$</td>
<td>8</td>
<td>4.00</td>
<td>$O_3$</td>
<td>4.00</td>
</tr>
<tr>
<td>$O_4$</td>
<td>6</td>
<td>3.00</td>
<td>$O_4$</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Step 7: The aggregation function will be the sum of Alpha-Beta product sum of Alpha's

Steps 8 & 9 will be read on the following tables:
<table>
<thead>
<tr>
<th>Beta value</th>
<th>Alpha value</th>
<th>Alpha-Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>0.2</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>0.3</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>0.4</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

**System A (large panels)**

Sum of Alpha's = 10.00
Sum of Alpha-Beta = 42

\[
\frac{\text{Sum of Alpha-Beta}}{\text{Sum of Alpha's}} = \frac{42}{10} = 4.2
\]

**System B (small components)**

<table>
<thead>
<tr>
<th>Beta value</th>
<th>Alpha value</th>
<th>Alpha-Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>0.2</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>0.3</td>
<td>9</td>
<td>36</td>
</tr>
<tr>
<td>0.4</td>
<td>8</td>
<td>24</td>
</tr>
</tbody>
</table>

Sum of Alpha's = 10.00
Sum of Alpha-Beta = 78

\[
\frac{\text{Sum of Alpha-Beta}}{\text{Sum of Alpha's}} = \frac{78}{10} = 7.8
\]

**Step 10:** If we compare the overall judgments, we see that System B ranks first and is desirable on the Beta scale, and System A is second and is undesirable.

b) **The Method of Paired Comparison**

This is a process for evaluating and weighting objectives in terms of importance, in order to rank them. In the Alpha-Beta method, this comes back to giving the Alpha judgments for the objectives. Basically, the method consists of taking each objective alone and comparing it to each one of the remaining objectives, and a judgment about the relative importance of this objective is made. The objective that will turn out to be more important than the larger number of objectives will rank first, and so on. A step-by-step delineation of the method will clarify it and will probably show that it is simpler than it seems from the explanation just given.

The first step will be to construct a matrix, with the objective listed on both vertical and horizontal axes. Let us assume five objectives:
The next step is to compare the objectives, two by two: Objective Oa in the row will be compared to objectives Oa, then Ob, then Oc, Od and Oe in the column. Then the same process is applied to Ob in the row. The question is asked, "Is the objective in the row more important than the objective in the column?" If we repeat the question as a?a, a?b, a?c, etc., the matrix will be:

Fig. II.3.

Two important points are brought to our attention in this matrix:

-- Every objective is compared to itself. This forms a diagonal in the matrix, where logically no judgments can be made, and which will therefore be left blank.

-- Every objective is compared twice to all the others, once on each side of the diagonal. Therefore, the decision-maker will carry out judgments for one side of the diagonal and simply mark the opposite judgment in the cells on the other side of the diagonal. In other words, if the answer to a?b is "yes," then the answer to
b?a will necessarily be "no."

Nevertheless, this can only be true if the rule of "no ties" is observed (no objective is allowed to be equal in relative importance to any other).

In cases where ties are allowed, the decision-maker will give the same value on both sides of the diagonal, in the appropriate cells. The values are usually recorded as follows:

--- No ties allowed: If the objective in the row is considered to be more important than the objective in the column, mark "1" in the cell of the matrix; if not, then mark "0".

Ex.: a?b = yes = 1  a?b = no = 0

--- Ties allowed: Same as when no ties are allowed, except when two objectives are judged to be of the same importance. In these cases, some theorizers suggest marking 1/2 in both cells where these objectives are compared. Others suggest giving "1" in both cells if objectives are considered to be important, or "0" in both cells if objectives are considered non-important.

To illustrate the preceding, we will take the same matrix as above, and will assign fictitious values to the judgments, using the ties-allowed rule, using the 1/2 value. The last step is then to sum the values in the rows and then rank the objectives; the one having the highest value will rank first, the second-highest second, and so on.

Fig. II.4.

```
<table>
<thead>
<tr>
<th></th>
<th>Oa</th>
<th>Ob</th>
<th>Oc</th>
<th>Od</th>
<th>Oe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oa</td>
<td>1</td>
<td>1/2</td>
<td>1/2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Ob</td>
<td>1/2</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oc</td>
<td>1</td>
<td>1/2</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Od</td>
<td>1/2</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oe</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

<table>
<thead>
<tr>
<th>Row Sum</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 1/2</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1 1/2</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

48
Returning to the Alpha-Beta method, the row sum represents the Alpha values, the "weights" that the decision-maker attributes to the objectives. If the Alpha values are decided to be normalized so that their sum equals 10.00, for instance, then $O_a = 2 \frac{1}{2} = 2.5$; $O_b = 2 = 2.0$; $O_c = 1 \frac{1}{2} = 1.5$, $O_d = 1 = 1.0$; and $O_e = 3 = 3.0$.

$$O_a + O_b + O_c + O_d + O_e = 2.5 + 2 + 1.5 + 1 + 3 = 10.00$$

c) The Churchman-Ackoff Method for Weighting Objectives

This is an alternative method to the paired comparison method. Grant (1976) describes it as being "a technique for deliberating relative importances among several objectives by means of trade-off judgments."

It is useful when (Grant, 1976):

"1. The objectives cannot be measured on a comparable scale or scales.
2. There are multiple objectives of potentially different degrees of importance.
3. The decision-maker finds the underlying assumptions acceptable."

These assumptions, axioms and corollary are stated in Churchman-Ackoff and Arnoff (1957) and Kaufman (1968):

**Axiom 1**: for every objective $O_i$, there is a real, non-negative number $V_i$ that can be interpreted as a measure of the true importance of objective $O_i$.

**Axiom 2**: If objective $O_i$ is more important than objective $O_j$, then $V_i > V_j$; and if $O_i$ and $O_j$ are equal in importance, then $V_i = V_j$.

**Axiom 3**: If we take objectives $O_k$ and $O_l$, then $V_k + V_l$ = combination of $O_k$ and $O_l$. This is the axiom of additivity. Given this axiom, the method can only be used in cases in which the objectives are discrete, non-contradictory, and mutually independent.
Corollary 1: If \( O_i \) is preferred to \( O_j \) and \( O_j \) to \( O_k \), then a set of objectives containing \( O_i \) and \( O_j \) is preferred to \( O_k \).

Corollary 2: The combination \( O_j \) and \( O_k \) is equal to the combination \( O_k \) and \( O_j \). That is, altered order of presentation does not alter preference.

Corollary 3: If the combination of \( O_j \) and \( O_k \) is equally preferred to \( O_k \), then \( V_j = 0 \).

Operational Assumption 1: An individual can make an estimate of \( V_i \) from a given scale (ex: 0.0 to 1.0) and this estimate provides some information about the value of \( V_i \).

Operational Assumption 2: The Churchman-Ackoff method can be said to provide a basis for the successive improvement of the estimated \( V_i \)'s.

We have seen that the method of paired comparison is based on comparing objectives in terms of relative importance, and the outcome of this comparison will be numerical values assigned to each objective according to its judged relative importance. As for the Churchman-Ackoff method, the values are estimated in the beginning, then checked throughout the procedure, and finally normalized. The checking of these estimates is based on a series of "trade-off" judgments, which are made by assuming two alternatives (systems): one that meets the most important of the objectives only, another that meets all of the objectives except the most important one. The question is: Which alternative is to be chosen? In other words, given objectives \( O_a \), \( O_b \), \( O_c \), and \( O_d \), with \( O_a \) more important than \( O_b \) (\( O_a > O_b \)) and \( O_b > O_c > O_d \). The judgment is made by comparing \( O_a \) to the combination of \( O_b \), \( O_c \), \( O_d \).

\[ O_a \leftrightarrow O_b \text{ and } O_c \text{ and } O_d \]

If \( V_a \) is the numerical estimated value of the relative importance of \( O_a \), and \( V_b \) of \( O_b \), \( V_c \) of \( O_c \), \( V_d \) of \( O_d \), then:

The comparison \( O_a \leftrightarrow O_b \text{ and } O_c \text{ and } O_d \) is the same as the comparison \( V_a \leftrightarrow V_b + V_c + V_d \).
The result of the second comparison should comply with the result of the first comparison. If not, then the numerical values have to be adjusted. The next step will be to compare \( \text{Ob} \iff \text{Oc} \) and \( \text{Od} \); then \( \text{Oc} \iff \text{Od} \). Again, we will go over the method on a step-by-step basis, as this should provide a better explanation and a more explicit description.

**Step I:** The decision-maker states his objectives, thus operates a nominal classification, and then makes off-hand judgments on their relative importance, therefore changing the nominal classification into an ordinal ranking. The most important objective becomes \( O_1 \), the second most important \( O_2 \), etc.

**Step II:** The decision-maker assigns values to the relative importance of his objectives. These numerical values (\( V_i \)'s) are off-hand estimates. The most important objective \( O_1 \) should be assigned a value \( V_1 = 1.0 \).

**Step III:** Let us assume six objectives: \( O_1, O_2, O_3, O_4, O_5, O_6 \).

Step III consists of:

--- writing the objectives with the most important to the left, second most important to the right of it, etc. i.e., \( O_1 O_2 O_3 O_4 O_5 O_6 \).

--- comparing \( O_1 \) to the combination of all remaining objectives, on the basis of the trade-off judgments described earlier i.e., \( O_1 \iff O_2 + O_3 + O_4 + O_5 + O_6 \).

There are three possible outcomes to this comparison:

1. \( O_1 > O_2 + O_3 + O_4 + O_5 + O_6 \) (\( O_1 \) is preferred to the others)
2. \( O_1 = O_2 + O_3 + O_4 + O_5 + O_6 \) (\( O_1 \) is considered equal to the others)
3. \( O_1 < O_2 + O_3 + O_4 + O_5 + O_6 \) (\( O_1 \) is less important than the combination)

--- If \( O_1 > O_2 + O_3 + O_4 + O_5 + O_6 \), replace the objectives by their respective judged values (\( V_i \)'s):

\[ O_1 > O_2 + O_3 + O_4 + O_5 + O_6 \] becomes \( V_1 > V_2 + V_3 + V_4 + V_5 + V_6 \)

If after replacing with the numerical values the equality holds,
we move to step IV. If not, $V_1$ should be adjusted so that it does, then move to step IV.

-- If $0_1 = 0_2 + 0_3 + 0_4 + 0_5 + 0_6$, replace by respective $V_i$'s and

$$0_1 = 0_2 + 0_3 + 0_4 + 0_5 + 0_6 \text{ becomes } V_1 = V_2 + V_3 + V_4 + V_5 + V_6.$$  

If after replacing with the numerical values the equality holds, we move to step IV. If not, $V_1$ should be adjusted so that it does, then move to step IV.

-- If $0_1 < 0_2 + 0_3 + 0_4 + 0_5 + 0_6$, replace by respective $V_i$'s and

$$0_1 < 0_2 + 0_3 + 0_4 + 0_5 + 0_6 \text{ becomes } V_1 < V_2 + V_3 + V_4 + V_5 + V_6.$$  

If after replacing with the numerical values the inequality holds, we move to step III.A. If not, $V_1$ should be adjusted so that it does, then move to step III.A.

**Step III.A:** This step consists of deleting the least important of the objectives, then doing the comparison between the most important and the combination of the remaining objectives. In other words, if we have a series of objectives $0_1, 0_2, 0_3, \ldots, 0_m$, step III.A. comes to comparing

$$0_1 \leftrightarrow 0_2 + 0_3 + \ldots + 0_{m-1}.$$  

In our case: $0_1 \leftrightarrow 0_2 + 0_3 + 0_4 + 0_5$ or

$$V_1 \leftrightarrow V_2 + V_3 + V_4 + V_5.$$  

Again, there are three possible outcomes to this comparison:

1. $0_1 < 0_2 + 0_3 + 0_4 + 0_5$
2. $0_1 = 0_2 + 0_3 + 0_4 + 0_5$
3. $0_1 > 0_2 + 0_3 + 0_4 + 0_5$

-- If $0_1 > 0_2 + 0_3 + 0_4 + 0_5$, replace by $V_i$'s.

If $V_1 > V_2 + V_3 + V_4 + V_5$ inequality holds, then move to step IV. If not, adjust $V_1$ and move to step IV.

-- If $0_1 = 0_2 + 0_3 + 0_4 + 0_5$, then $V_1 = V_2 + V_3 + V_4 + V_5$ should hold. If not, adjust $V_1$ and move to step IV.

-- If $0_1 < 0_2 + 0_3 + 0_4 + 0_5$, then $V_1 < V_2 + V_3 + V_4 + V_5$ should hold. If not, adjust $V_1$ and move to step III.B.

**Step III.B:** Same as step III.A, except that:

$$0_1 \leftrightarrow 0_2 + 0_3 + \ldots + 0_{m-1} \text{ becomes } 0_1 \leftrightarrow 0_2 + 0_3 + \ldots + 0_{m-2}.$$  

In our case, $0_1 \leftrightarrow 0_2 + 0_3 + 0_4$ or $V_1 \leftrightarrow V_2 + V_3 + V_4.$

Again, if $0_1$ is judged more important than the combination, adjust
V₁ and move to step IV. The same if O₁ is considered equal to the combination.

If O₁ is considered less important:

0₁ < O₂ + O₃ + O₄ and V₁ < V₂ + V₃ + V₄.

Adjust V₁ and move to step III.C.

Step III.C: Same as step III.B, except that:

0₁ ⇐> O₂ + O₃ + ... + Oₘ₋₂ becomes 0₁ ⇐> O₂ + O₃ + ... + Oₘ₋₃.

In our case, 0₁ ⇐> O₂ + O₃ or V₁ ⇐> V₂ + V₃.

For the three outcomes, replace the values and adjust V₁, so that the inequalities or equality hold, then move to step IV.

Step IV: Record the final V arrived at after all adjustments, then drop 0 from the comparison process. The comparison becomes:

0₂ ⇐> O₃ + O₄ + O₅ + O₆.

Repeat step III through all the outcomes and the sub-steps if necessary, until:

0₂ ⇐> O₃ + O₄.

Adjust V₂ all along the process.

Record the final V, then move to step V.

Step V: Drop O₂ from the comparison process and compare

0₃ ⇐> O₄ + O₅ + O₆.

Repeat step III through all the outcomes and sub-steps if necessary, until:

0₃ ⇐> O₄ + O₅

adjusting V₃.

Record the final V₃ and move to step VI.

Step VI: Drop 0₃ and compare 0₄ ⇐> O₅ + O₆.

Repeat step III, adjusting V₄.

Record the final V₄ and move to step VII.

Step VII: This step consists of normalizing all the Vi's into Wi's (normalized values).
The sum of all $W_i$'s will equal 1.00.

The $W_i$'s will correspond to the Alpha values in the Alpha-Beta method.

The preceding procedure is, in fact, only suitable for six or fewer objectives. With seven or more objectives, the procedure is fundamentally the same, with differences in the staging process.

**Step 1** will be the nominal classification and the ordinal ranking.

**Step 2** consists of randomly selecting one objective, $O_s$. Then, again randomly, dividing the remaining objectives in groups of no more than five objectives, and preferably of equal size.

$O_s$ will be assigned a value $V_s = 1.00$ and added to each of the subgroups. The remaining objectives other than $O_s$ should occur only in one group each. $V_i$'s values are assigned to the objectives based on the standard $V_s = 1.00$.

**Step 3** is to repeat steps III to VI of the preceding procedure, for each of the subgroups, with $V_s = 1.00$ remaining unchanged. The outcome will be a set of non-normalized values for the objective.

**Step 4** is to operate a new ranking for the objectives, in accordance with the $V_i$'s derived from step 3.

Compare the ranking obtained with the ranking in step 1.

If they are in accordance, normalize the values using the same equation as in step VII:

$$W_i = \frac{V_i}{\text{sum of } V_i}$$

If the two rankings differ, we might want to reconsider the first ranking (step 1) or repeat the procedure.

When a consistent result is reached, we normalize the $V_i$'s.

An example of this procedure is described in "Churchman C.W.; Ackoff, R.L.; Arnoff, E.L., Introduction to Operations Research, 1957, New York: Wiley & Sons."
Fig. II.5: Churchman-Ackoff Method for Weighting Objectives

**STEP I** Nominal classification, then Ordinal ranking \( (O_1, O_2, O_3, O_4, O_5, O_6) \)

**STEP II** Assigning estimated values \( V_i \)'s, with the most important \( V_1 \).

**STEP III** Compare \( O_i \leq \sum_{j=1}^6 O_j \)

1. \( V_1 \geq V_2 + V_3 + V_4 + V_5 + V_6 \)
2. \( V_1 \leq V_2 + V_3 + V_4 + V_5 + V_6 \)
3. Adjust \( V_1 \)

**STEP IV** Compare \( O_1 \leq \sum_{j=1}^5 O_j \) (After recording the \( V_i \) arrived at)

1. \( V_1 \geq V_2 + V_3 + V_4 + V_5 \)
2. \( V_1 \leq V_2 + V_3 + V_4 + V_5 \)
3. Adjust \( V_1 \)

**STEP V** Compare \( O_2 \leq \sum_{j=1}^5 O_j \) (After recording the \( V_i \) arrived at)

1. \( V_2 \geq V_3 + V_4 \)
2. \( V_2 \leq V_3 + V_4 \)
3. Adjust \( V_2 \)

**STEP VI** Compare \( O_3 \leq \sum_{j=1}^4 O_j \) (After recording the \( V_i \) arrived at)

1. \( V_3 \geq V_4 \)
2. \( V_3 \leq V_4 \)
3. Adjust \( V_3 \)

**STEP VII** Compare \( O_4 \leq \sum_{j=1}^3 O_j \) (After recording the \( V_i \) arrived at)

1. \( V_4 \geq V_5 \)
2. \( V_4 \leq V_5 \)
3. Adjust \( V_4 \)

**STEP VIII** Compare \( O_5 \leq \sum_{j=1}^2 O_j \) (After recording the \( V_i \) arrived at)

1. \( V_5 \geq V_6 \)
2. \( V_5 \leq V_6 \)
3. Adjust \( V_5 \)

**STEP IX** Compare \( O_6 \leq O_1 + O_2 + O_3 + O_4 + O_5 \)

1. Adjust \( V_6 \)

**STEP X** Record the \( V_i \) arrived at, then normalize \( V_i 's \) into \( W_i 's \) by

\[
W_1 = \frac{V_1}{V_1 + V_2 + V_3 + V_4 + V_5 + V_6}
\]
Up until now we have been discussing and describing methods of evaluation, on an individual basis. We referred to the decision-maker, where, in fact, we know that decisions are rarely made by one single individual (at least as far as building projects and building systems are concerned), and the decision-making process involves several participants. Thus, we have yet to incorporate the methods we described into an evaluation procedure for groups. Churchman, Ackoff and Arnoff in "Introduction to Operations Research" (1957, Wiley) write about group decision-making (pp. 132-135). Horst Rittel of the University of California at Berkeley proposed a method of evaluation for groups. In the following paragraph, we will relate the procedure as described by D. Grant in "How to Use the Alpha-Beta Model for Decision-Making with Multiple Objectives" (May 10, 1976, revisions through August 20, 1976) and in DMG & DRS Journal Vol. 10, no. 4, Oct.-Dec. 1976 (pp. 208, 209).

d) Rittel's Evaluation Procedure for Groups

Step I: Each member of the group makes an off-hand, overall judgment.

Step II: Each member makes a list of the aspects or parameters that are important (objectives).

Step III: Each member weights the objectives to indicate his judgment concerning relative importance among themselves (Alpha values).

Wait one to two weeks, then repeat steps I through III. Discard the first results and keep the second.

Step IV: Assemble a union list of aspects/parameters (objectives) made up of all those submitted by all members of the group. Edit the union list to eliminate repetition.

Step V: Distribute the edited union list to all members of the group and ask them to weight the objectives in accordance with their judgments concerning relative importance among themselves (Alpha values).
Step VI: Each member of the group scores each alternative (or system) against each objective on the union list (Beta values).

Step VII: Overall deliberated scores are computed (Alpha-Beta values).

All the group's deliberations up to this point may have taken place without a face-to-face meeting.

Step VIII: Compare each individual's off-hand judgment from step I with his deliberated judgment from step VII.

Step IX: The result of the first eight steps is a deliberated, overall judgment.

The role of each individual person in the process may be anonymous up to this point; this is desirable if the participants are of unequal rank or prestige.

A face-to-face meeting might be considered at this stage.

One of the functions of such a meeting is to discuss whether the results of step VIII are to stand as the group's decision.

a. The pre-weighting of the aspects can be used to generate the right arguments, and to avoid wasting time on trivial matters.

b. People may arrive at similar overall judgments for quite different reasons. Cases of extreme disagreement can be analyzed and discussed by searching for widely divergent weighting and scoring judgments from steps V and VI.

c. The group may decide to deliberate further in areas of major disagreement, perhaps generating research or simulation projects in the process, or to repeat the entire cycle, or to break down some important aspects into sub-aspects and/or to construct more detailed criterion functions.

Step X: Either decide to act upon the deliberated judgment of step VIII or to recycle or revise, as described in step IX.
e) Conclusion

The methods described in the preceding paragraphs might differ in terms of complexity or levels of accuracy, but one could say that they are all "generic" in the sense that they could be applied to a multitude of very differing cases. They should be seen as a tool for reaching "thought" decisions. Moreover, by fragmenting the general goal into a series of specific objectives, the methods can help determine the precise points of strength or weakness of the alternatives, in responding to the needs of the decision-maker. Based on this reasoning, the following chapter will be an attempt to apply the methods to the context of this study--the U.A.E.--in order to analyze building systems from an industrial point of view. Toward that purpose, the "Alpha-Beta method" and the "method of paired comparison" will be used.
III- Implementation
The first chapter of this work, in analyzing the situation in the U.A.E., has shown that building systems are not to be approached as a means of resolving a virtually nonexistent housing shortage, but as an industry capable of generating a potential revenue on a national scale. Moreover, the "alternatives" to be evaluated have to be seen in broad terms, as it is not possible to advocate a very specific system if the system's approach itself has not been defined. Therefore, it seems more appropriate, as a first step, to put the problem forth as a choice between "open systems" and "closed systems," as defined below. The second step will look at the consequences of the choice, in terms of specific suggestions or directives that are deemed helpful in implementing the chosen system. At this point it should be understood that:

-- **Open systems** consist of standard components manufactured and catalogued. These components are interchangeable with those of other manufacturers and other systems. In other words, it is a system having externalized interchangeability of its subsystems (Study of Educational Facilities, SEF, 1968).

-- **Closed systems** consist of components that are peculiar to these systems and cannot be combined with those of another system. In other words, it is a system having internalized interchangeability of its subsystem (SEF, 1968).

-- **Subsystems** are an identifiable, complete, designed, physically integrated, dimensionally coordinated installed series of parts which function as a unit within prescribed performance limits (SEF, 1968).

Although the main focus of this study is a building systems industry geared towards exports, the local market also has to be taken into consideration. Though not a necessary requirement, it would be most desirable for the export alternative to respond to the local market's needs as well. Therefore, an
evaluation of both open and closed systems will be conducted on the local market level. This should help in assessing the compatibility of the export alternative with the local needs.

Before proceeding any further, however, it should be noted that the evaluations carried out in the following paragraphs were done on an individual basis. They represent the author's perception of the situation. It is clear that a team of experts comprising an economist, an investor, a contractor, an architect, a policy-maker, etc. would set a series of more accurate and explicit objectives. Unfortunately, it is beyond the scope of this thesis to organize such a team. Therefore, an attempt was made to list the objectives, to remain as "generic" as possible, yet be relevant; there was no pretense of objectivity.

a) The Local Market

Objectives

Based on the extrapolation from the data contained in the first chapter, along with empirical personal evidence gained through various business visits and interviews in the U.A.E., the following set of objectives was established. These objectives are obviously generic and do not pretend to be exhaustive. Nevertheless, the combination of these objectives is capable of verifying the assumption that building systems are not an exclusive mode of consumption in the local market. On the other hand, the evaluation will help determine the alternative that would be more suitable in the eventuality of the use of building systems.
Oa - Minimize initial investment
Ob - Minimize writing-off period
Oc - Short-term returns
Od - Product line: continuous product desired
Oe - Maximize local business management
Of - Short-term foreign technical supervision
Og - Short-term foreign site supervision
Oh - Maximize consumption of locally produced materials
Oi - Minimize imports
Oj - Short "learning curve"
Ok - Urban centralization of production plants
Ol - Scattered sites favored
Om - Road transportation: medium- to light-weight equipment
On - Handling off-site: manual and medium- to light-weight machinery
Oo - Handling on-site: manual and medium- to light-weight machinery
Op - Simple on-site assembly
Oq - Minimize erection time
Or - System should allow variation on generic floor plan
Os - Units height: 1-2 stories
Ot - Finishing: semi-finished
Ou - Life cycle: 5-10 years
Weighting the Objectives, Using the Method of Paired Comparison

(the "ties-allowed" rule will apply, with $\frac{1}{2}$ given to both objectives)

|   | Oa | Ob | Oc | Od | Oe | Of | Og | Oh | Oi | Oj | Ok | Ol | Om | On | Op | Oq | Or | Os | Ot | Ou | Score | Rank | Normalized Alpha value |
|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|------|-----|-----------------------|
| Oa | 0 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 | 6 | 12 | 2.86 |
| Ob | 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 1 1 1 1 | 7 | 12 | 5.71 |
| Oc | 1 1 1 1 1 0 0 0 1 1 1 0 0 0 0 1 1 1 1 | 8 | 11 | 5.48 |
| Od | 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 1 | 11 | 3.1 |
| Oe | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 | 13 | 1.9 |
| Of | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 | 13 | 1.9 |
| Og | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 | 14 | 1.2 |
| Oh | 1 1 1 1 1 1 0 0 1 1 1 1 0 0 1 0 1 1 1 1 1 | 3 | 8.09 |
| Oi | 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 | 9 | 5.23 |
| Oj | 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 | 11 | 5.48 |
| Ok | 1 1 0 0 1 1 1 0 1 1 0 1 0 0 0 0 0 0 1 1 | 8 | 6.43 |
| Ol | 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 0 0 0 0 0 0 6 | 3.1 |
| Om | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 17 | 2 | 8.33 |
| On | 1 1 1 1 1 1 1 0 1 1 0 1 0 0 0 0 1 1 1 1 1 5 | 4 | 7.38 |
| Oo | 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 0 1 1 1 1 1 15 | 5 | 7.14 |
| Op | 1 0 0 0 1 1 1 0 1 0 1 1 0 0 0 0 0 0 1 1 1 10 | 10 | 4.76 |
| Oq | 1 1 1 1 1 1 0 1 0 1 0 1 0 0 0 0 0 1 1 1 1 11 | 8 | 5.48 |
| Or | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 19 | 1 | 9.28 |
| Os | 1 0 1 1 1 1 1 1 1 0 0 1 1 0 0 0 0 0 1 1 1 11 | 8 | 5.48 |
| Ot | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 2 | 14 | 1.2 |
| Ou | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 15 | 1 | 0.47 |

Alpha total: 100.0
### The Alpha-Beta Model

#### Beta value

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**Sum of Alphas** 100.00  **Sum of Alpha-Beta** 573.86  **777.84**

#### Beta scale:

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<td>Excellent satisfaction</td>
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<tr>
<td>8</td>
<td>Good satisfaction</td>
</tr>
<tr>
<td>7</td>
<td>Average satisfaction</td>
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<td>Moderate satisfaction</td>
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<td>Indifferent satisfaction</td>
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<td>Poor satisfaction</td>
</tr>
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<td>No satisfaction</td>
</tr>
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<td>2</td>
<td>Very unsatisfactory</td>
</tr>
<tr>
<td>1</td>
<td>Totally incompatible</td>
</tr>
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By using the aggregation form \( \frac{\text{Sum of Alpha-Beta}}{\text{Sum of Alpha}} \),

"closed systems" score \( \frac{573.86}{100} = 5.73 \) which on the Beta scale is equivalent to Indifferent-to-Moderate satisfaction. "Open systems," on the other hand,
The results are evidently in favor of an "open systems" approach. In fact, this has been anticipated, in the sense that the existing data show that the infrastructure necessary for the implementation of "closed systems" does not at the moment constitute a favorable basis for an investment in that direction. Another important point is that if the evaluation favors an "open systems" approach over a "closed systems" approach, the former falls only in the "average-to-good satisfaction" bracket on the desirability (Beta) scale. This confirms the assumption previously derived from the data. That is, building systems as a panacea for the housing problem in the U.A.E. cannot be justified, in view of the characteristics and future requirements of the local market. Thus, building systems may be assumed to constitute a possible source of greater efficiency, speed, etc., but are not necessarily vital for the internal market's survival.

b) The Export Industry

As mentioned before, the focus of this work is building systems, as an industrial approach on the national scale, which will have a production directed mainly towards exports. The following evaluation was conducted in order to determine the most appropriate approach ("open systems" vs. "closed systems"). Once the approach has been defined, more specific recommendations will be given, as guidelines for the implementation of the building systems industry.
The Objectives

Once again, it should be noted that these objectives, resulting from the extrapolation from the given data, along with empirical evidence, were kept on a "generic" level.

Oa - Maximize local business management
Ob - Short-term foreign technical supervision
Oc - Maximize consumption of locally produced materials
Od - Minimize imports
Oe - Optimize function product mix
Of - High compatible product quality control
Og - Maximize facilitation of entry into foreign markets
Oh - Maximize compatibility with prevailing standards
Oi - Minimize per-unit cost of transportation
Oj - Reduce complexity of components' assembly
Ok - Minimize adaptability to various layouts
Ol - Minimize stages of handling process
Om - Maximize variety of possible combinations
On - Minimize basic series of components
Oo - Maximize interchangeability of components
Op - Allow diversification of capital investment
Oq - Allow short- and long-term capital amortization
Weighting the Objectives, Using the Method of Paired Comparison

(the "ties-allowed" rule will apply, with \( \frac{1}{2} \) given to both objectives)

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Alpha Total 100.0
### The Alpha-Beta Model

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**Sum of Alphas** 100.00  **Sum of Alpha-Beta** 503.30  828.65

#### Beta scale:

- 9 = Excellent satisfaction
- 8 = Good satisfaction
- 7 = Average satisfaction
- 6 = Moderate satisfaction
- 5 = Indifferent satisfaction
- 4 = Poor satisfaction
- 3 = No satisfaction
- 2 = Very unsatisfactory
- 1 = Totally incompatible

By using the aggregation form \( \frac{\text{Sum of Alpha-Beta}}{\text{Sum of Alpha}} \), which on the Beta scale is equivalent to Indifferent Satisfaction. "Open systems," on the other hand, score \( \frac{828.65}{100} = 8.28 \) which on the Beta scale is equivalent to Good-to Excellent Satisfaction.
Assessment

The evaluation, once again, is clearly in favor of the "open systems" approach. Therefore, it seems warranted, given the comparison of the results of the two evaluations (local/export), to assume that an export-geared "open systems" industry would ultimately also answer the local market's needs. Nevertheless, it should be noted that while in the local market's case it was the context (i.e., the U.A.E.) that constituted the primary determining influence, in the case of exports it was more the nature of "open systems" themselves that acted as the implicit determinant.

"Open systems" have the inherent capability of adapting to various situations without causing any major changes to their elements; hence, they are capable of satisfying larger and more diversified markets. This implies, however, a high level of compatibility and interchangeability. These factors are the essence of "open systems" and are mainly achieved through norms and specifications that the systems follow or even engender. Thus an "open systems" industrialization is not only producing elements and components, but also—and primarily—establishing and applying the codes and norms that would enable these elements to reach an optical degree of interchangeability and compatibility. The following chapter is an attempt to define the requirements and consequences of an "open systems" industrialization.
IV- Strategy
In general terms, conventional building is a process involving two main functions: design and construction. The industrialization of building brought in a new function: production. Components and parts of buildings were produced in factories, then brought to the site for assembly with other parts fabricated on-site. It was then possible to incorporate industrially produced components of different origins in the same building. Mass production of these components, however, was made difficult due to the variety in their sizes. Rationalization of building production was necessary in order to facilitate large numbers production. This introduced the concept of standardization. Standard dimensions were given to components in order to reduce the number of possible sizes, yet optimize the possible combinations. This, in turn, made mass production of these components possible and economically sound.

However, the number of industrially produced building components used in construction was steadily increasing, thus making dimensional standardization on its own insufficient: parts and components had to "fit" with other components and parts, therefore sizes and dimensions had to be made compatible. This was achieved by dimensional coordination. Dimensional coordination has been defined by the International Organization for Standardization (ISO) as "a convention on related sizes for the coordinating dimensions of building components and the building incorporating them, for their design, manufacture and assembly" (ISO Recommendation R 1791; 1971).

As dimensions became the common denominator between the components, a common base or language had to be adopted in order to facilitate communication between designers, manufacturers and constructors. Therefore, an international
agreement founded dimensional coordination in building on a **basic module** and **multimodules** (hence, **modular coordination**). The basic module was defined as "a unit of length which has been selected to achieve dimensional coordination, reduction in the variety of component sizes and maximum flexibility and convenience in design and production" (Dimensional Coordination in Building, United Nations, 1974). "The basic module is represented by the letter M. The international standardization value of the basic module is \(1M = 100\text{mm}\)" (ISO Recommendation R 1006; 1969).

To summarize: Rationalization of production, standardization, dimensional and modular coordination, in establishing the limitation of the range of components, hence facilitating mass production, along with optimizing interchangeability and compatibility among the components, constitute the basis of building industrialization in general, and more specifically of the "open systems" approach. Hence, an "open systems" approach to an export-gearied building industrialization in the U.A.E. is the process of articulating the above-mentioned factors into a marketing process related to production and delivery. This could be divided, in broad terms, into four phases:

-- Phase I: Identifying the market
-- Phase II: Analyzing the market
-- Phase III: Assessing and adapting local production
-- Phase IV: Marketing

It should be made clear that the order in which these phases are listed is not necessarily chronological, but more of a "criteria generating" sequence, in the sense that the first phase would help determine the criteria for the second phase's process, which in turn would set the criteria for the third phase's evaluation, and so on. The actual process, though, should be seen as
a whole, as the interaction between the criteria is inevitable and necessary.

Phase I: Identifying the Market

It would be "premature" to assume that since the U.A.E. has the means to manufacture products of very high quality that these products would automatically become competitive. The long past experience and know-how, in terms of production and marketing techniques of countries where building industrialization has reached a very advanced level would necessarily affect the marketing of the U.A.E. products. Therefore, any advantages that the U.A.E. might have over such countries have to be exposed and the market has to be defined accordingly.

The geographical situation of the U.A.E. gives it a definite advantage in terms of a significant reduction of transportation distances--hence costs--between the industrialized countries and the potential Middle Eastern and African markets. Moreover, the social, cultural and political ties that the U.A.E. has with most of the Middle Eastern and some African countries would play an important role in promotion of the U.A.E.'s products. Henceforth, it seems appropriate, as a first stage, to concentrate the market in the Middle East (the Gulf region, Lebanon, Syria, Iraq, Jordan, Egypt and the Sudan) and, to a certain extent, Iran, India and Pakistan.

Phase II: Analyzing the Market

The market defined previously is in fact very complex, in that it consists of countries with different levels of national income, G.N.P, technology, different public and/or private building policies, different standards, etc. A detailed and in-depth market analysis should determine the
"demand" in terms of production determinants, e.g., quality, quantity, type, standards. Accurate studies should be made in order to define the "functional types" of building. In other words, if housing is in much larger demand than office buildings or industrial complexes, for instance, it might be advisable to concentrate production in that direction; if the demand is more balanced, a greater "functional product mix" would be more appropriate.

Another important factor is the quantity. It is necessary to assess demand in quantitative terms, on short- and long-term (projected) bases. This factor is of paramount importance, as its impact on production goes from the initial investment stage to production and delivery scheduling. Also, the locational concentration of the demand should be examined, as it will help in determining the most economical and practical transportation routing. Although it is usually assumed that high quality is always more in demand than low quality, markets can be found where an optimal mix of possibly lesser quality at lower costs is acceptable or preferred. This would affect export production and each market consequently should be analyzed.

While the factors previously cited--i.e., quality, quantity, type--though specific, could be discussed in global terms, the problem of standards and coordination is of a different nature. The wide spectrum of socio-cultural and political entities that constitute the cited markets will reflect on existing standards. Since the nature of these entities is one of previously colonized "developing" countries, one is most likely to find standards deriving from previous or current technical cooperation ventures or schemes between these countries and the industrialized Western nations. Equally, economical and political systems also affect standards, in the sense that in free-trade economies, standards emanate from the normalization of a competitive market, unlike Socialist systems, where standards are usually set
by governmental institutions or by fiat.

Therefore, the market analyst's task is to identify prevailing standards and evaluate them in terms of their origins, implementation and coordination within each country, separately, and in the market as a whole. Ultimately this would help in determining the optimum basic module or set of modular entities that will tend towards unifying and establishing modular coordination between producers, designers and consumers. This topic will be discussed later in the chapter.

Phase III: Assessing and Adapting Local Production

As seen in the first chapter, industrial development in the U.A.E. has already started, and although the building sector's share of that development is at an early stage it is necessary to take it into account. Production has to be assessed and evaluated against criteria derived from the market analysis. In order to do so, a team of experts should be formed. This team's first task would be to develop a format for collecting information from manufacturers. (The constitution and status of the team will be discussed later in the chapter.) The format should contain sections such as:

--- General description: -type of product
-use
-standards applied (if any)
country and firm of origin, if product is manufactured under license
-etc.

--- Composition, method of manufacture:
-materials in composition
-method of preparation
-manufacturing process
-finishing
-etc.
-- Physical and general appearance:
- dimensions
- weight
- volume
- sections
- texture
- color ranges
- etc.

-- Physical, chemical and biological properties:
- thermal properties
- accoustical properties
- strength
- resistances
- fire safety
- permeability
- etc.

-- Technical properties:
- installation
- equipment
- joints
- tolerances
- etc.

-- Design considerations:
- interchangeability
- replaceability
- repairability
- durability
- architectural and constructional details
- references to finished constructions
- etc.

-- Instructions for work and maintenance:
- type of labor
- technical supervision
- erection
- handling
- maintenance
- etc.

-- Delivery:
- production and supply capacity
- packing
- conditions of delivery
- etc.

-- Costs

(Note: This list is only an example. For more comprehensive formats, refer to Rosen, H. and Bennett, P; Construction Materials Evaluation and Selection, New York: Wiley, 1979)
Once the format is established, the "forms" would be sent to manufacturers, who would be requested to fill in the appropriate information and return it to the team. The data will then have to be processed, and the result should be an accurate assessment of the state of local production, as it will accomplish the following:

-- categorize products, in terms of types, materials, uses, etc.
-- determine prevailing standards
-- determine quantities and production capacities
-- determine if and in which areas accurate research and testing are required.

The next step then becomes to evaluate local production against the export market's demand. This process should define the sectors where production has to be increased, controlled, regulated or created. It will also determine whether local standards are compatible with those prevailing in the export market. For that purpose an institution has to be created that will adapt local standards to those of the export market. The common basic module or set of modules will have to be identified, as this would facilitate modular and dimensional coordination between the elements, therefore increasing their interchangeability and compatibility, hence their "marketability."

At this point, the question of how to achieve modular coordination arises. One possibility is by regulations and decrees that would impose specific standards and modules on manufacturers. This method is not advisable, as regulations and codes, although necessary in many cases, have been found to hinder innovations. The other possibility is the "dissemination of information." This method consists basically of keeping a constant information flow between boards of standards, research institutions, testing laboratories, designers, and manufacturers. The competitive nature of a free trade system such as the U.A.E.'s will systematically draw the manufacturers towards
complying with the advocated standards, as this might insure greater markets and larger profits. This method is deemed more appropriate for the U.A.E. as it not only follows the economic and political line of the country, but it has also the ability to induce technical innovations by enhancing competition among manufacturers.

Finally, research and testing laboratories should be created in order to keep a permanent updating of the innovations in building technology, and also to develop and test new materials, elements, techniques, etc. These laboratories could operate within, or in close cooperation with, universities and other educational institutions, as this would not only promote technology, but also, on the educational level, form local experts and technicians, who would constitute the future cadres of the industrialization mechanism.

Phase IV: Marketing

The key word in this phase is, again, "information." A constant, updated information flow has to be kept between manufacturers in the U.A.E. and designers and constructors in the export market. This could be done by means of catalogues and periodical publications that would keep an update on the state of production. Also international seminars and building technology exhibitions could be organized, as they enhance communication between designers, constructors and manufacturers. Again, these are only suggestions, and more detailed marketing studies have to be conducted by marketing specialists.

Up to this point, recommendations on policies have been made, and policy-makers have yet to be defined. Teams, boards and institutions have to be created, in order to implement building industrialization. As mentioned earlier, models are known where the government is in full control of
the industrialization policies. These models usually are those of Socialist countries, in which governments set standards, control production and handle construction. All boards and institutions are government bodies. This model is not seen as appropriate to the U.A.E.: it generally produces "closed systems" and limits the incentives and possibilities of a free market such as the U.A.E. Therefore, it is the building industry itself that has to implement industrialization, through trade organizations such as the Chamber of Commerce and Industry (C.C.I). Some institutions to be created by the C.C.I could be temporary:

--- the market analysis team, whose function is to define the export market and analyze it in terms of production determinant

--- the local production assessment team, which will collect and process local production data in order to evaluate it against the export market's demand

The other institutions will be permanent and will implement and control building industrialization. Some of these institutions are:

--- the Board of Standards, which will define standards, establish modular coordination and insure a constant communication between designers, constructors and manufacturers

--- research institutes and testing laboratories working in cooperation with universities

--- a Certification Board, which, following the French agréments model, would "certify" new products through testing and research; certification is made basically in terms of comparison with reputed, well-established products. This would insure "credibility" (if certification is obtained) of new products, and therefore encourage innovations.

--- a marketing team, whose task is to ensure optimal flow of distribution of U.A.E. products in the export market

--- a legal advisory board, which would provide legal assistance to firms in negotiating contracts, joint ventures, and in settling commercial disputes.
Other institutions could also be formed independently of the C.C.I., following the "Bowcentrum" model in Holland. The Bowcentrum (Building Centre) is an independent institute, legally constituted a Foundation, it operates with no subsidies on a non-profit basis. This institute's work involves "research, consultancy and development work, documentation, information and training in the fields of building and housing in the widest sense of these terms.... Bowcentrum makes its services available to all groups of people involved in building and housing: decision-makers, builders, designers as well as the user, the consumer" (Union Internationale des Centres du Bâtiment, Bulletin 1-80, Bowcentrum, Netherlands, 1980).

The U.A.E.'s version of the Bowcentrum would be a Building Centre involved in setting up training and instruction seminars, international conventions, and organizing exhibits on permanent and periodic bases, in order to promote research and establish accurate communication and information flow.

All of the above-mentioned boards and institutions, though part of the private sector, will have to operate on close terms with government agencies, as the government has not only means to provide incentives on the national scale, in terms of investment, loans to manufacturers, industrial land allocation, subsidies, etc., but also on an international scale, in the sense that long-term credits could be negotiated with foreign governments in the form of very low priced U.A.E. products, which in turn would be subsidized in the U.A.E. This would increase these products' ability to compete and would provide the prospect of larger and broader markets.
Conclusion
The analysis of the existing data has shown that the government of the U.A.E. is clearly adopting a policy of diversification of the economy. The overall assumption that building systems should be considered as a potential source of national revenue has thus been validated.

Verification of that assumption was made by formal testing, and an "open systems" approach to the building industrialization process is being recommended. The inherent properties of the "open systems" approach, along with the special conditions of the U.A.E., resulted in a set of recommendations on the strategy to follow, in order to recast existing structures and create the institutions capable of implementing an export-geared industrialization of the building sector. It is within that particular scope that this work should be seen as a document on policies for the implementation of a building industrialization in the U.A.E.

Nevertheless, this work does not pretend to total objectivity, nor to exhaustiveness. Further studies will have to be conducted by the appropriate experts and technicians, within the framework advocated, in order to detail and analyze in depth each phase of the suggested process. It is the considered opinion of the author that a building industrialization along the lines of this thesis would benefit not only the U.A.E. but the entire Middle East region as a whole.
Bibliography


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