Research Objective:
The aim is to point out the possibilities of reducing costs for the construction of blocks of flats, particularly by increasing the quality of the design and preparation of the execution. Therefore, it is necessary to use qualified labour and proper building materials of a good quality and to provide a high-quality and safe execution of construction work in the whole process of the project’s preparation and realization. The measures improving the investment process are aimed at the primary objective, which is to achieve the economic efficiency for the construction of flats.

Foreword:
Having a house or flat of one’s own is the objective of every citizen, but the high costs for the construction of flats do not enable each family in Yemen to buy their own flat. Therefore, the state must establish such conditions for entrepreneurs in the construction business that these companies would be stimulated to execute construction projects as cheaply as possible (e.g., competition, invitation for tenders).

The task of civil engineering specialists is to look for methods to decrease the total costs for construction projects. As an Arabic saying goes, need is the mother of discovery. Firstly the reasons for the high costs of the construction of flats must be found. We assume that this problem can be solved mainly by designers in Yemen so that they will make an effort to eliminate factors that cause an increase of construction costs. The designers must design each project by taking into consideration the particular conditions of the building’s location and the climatic conditions of the locality. It is inappropriate to
realize the same project in the mountains and by the sea, which has happened in several cases. Furthermore, they should consider the use of available building materials, the dimensions of imported building materials on the market (e.g., the length of steel), make tests of the load-bearing capacity of the soil, and accordingly design the foundations and make the scheduling for the project’s realization. If all the mentioned negative impacts meet in a project and are not solved, the total project costs could be increased by 20%.

Of the above reasons the research was focused on the issue of the increase in total costs for the realization of a construction project or to find possibilities for their reduction. The aim is to achieve an economical project, which means to design and subsequently realize a construction project with the required efficiencies, of high quality and a long service life, in an optimum time and at the lowest possible cost. Not only reduction of the one-time investments for a project’s realization but also the minimization of future operating costs and costs for repairs and maintenance during the service life of the building should be considered. Such a project will be economical when we make an effort to minimize the total costs for its design and realization, as well as utilization.

The objective is that the state should use a loan from a finance development bank to build as many flats as possible instead of pulling down or reconstructing flats which are not even 50 years old because they were poor quality constructions. All of us know that achieving economies means good management to achieve profits in a company; the company should analyze itself and open up to new ideas. We would like to say that a project documenting and taking into consideration its economic solution will help a lot of people to reduce flat acquisition costs and use natural resources in an optimum way which does not require financing. The research is focused on two main factors influencing the costs for a construction project:

1. Natural conditions (geological, climatic) at the locality of the construction project
2. Economic, architectonic and structural design of projects, (economic solution of project documentation).

1 NATURAL CONDITIONS AT A CONSTRUCTION LOCALITY

1.1 Design

The project documentation should take into consideration the conditions of a project’s locality so that a comfortable interior environment for the occupant should be created. This will also reduce the costs for building operations, e.g., energy consumption for lighting and air conditioning during the entire lifetime of the building. Saving operation energy using industrially produced thermal insulation in flats is not only very expensive in practise, but also harmful for the environment. In this respect, it is therefore better to use natural insulation materials such as wood or clay. Architectonic design plays an important role in regard to the reduction of material and energy consumption as well as the amount of labour. For example, if an architect designs the height of windows 1.6 m instead of the commonly used height of 1.0 m, an awall lintel will be not necessary, and the use of material as well as labour consumption will be reduced. The costs saved can be used for the realization of other parts of the project.

Certainly, there are also design conditions which must be observed, such as:

For each room of a flat temperatures that are defined by a standard. In cases that are due to poor design, the temperature reached in a room that is higher by 10 °C than that defined by the standard, harmful substances will be released into the environment from the chemical building materials used. The designer must observe the conditions for the design as well as the natural conditions resulting from the construction locality to achieve lower energy consumption during the service life of the building. German research studies of 1978 proved that the operational energy of a common flat consumed for a period of 60 years was 3,300,000 kw/h. After the flat was reconstructed using natural building materials, the energy consumption was reduced to 600,000 kw/h [7]. This means that the monthly costs of the energy consumed were reduced from 500 dollars to 72 dollars.

1.2 Use of local building materials

The use of local building materials has an important impact on the reduction of costs for a building project. In Yemen there is a big difference in costs for the construction of blocks of flats, particularly in the region of Wadi Hadramoutu, where clay as well as reinforced concrete flats are built. In 2000, clay blocks of flats were built for 13 D/m³ of built-up rooms and reinforced concrete blocks of flats for 35 D/m³ [2]. This means that a clay flat with an area of 150 m² and a clear height of 3.5 m cost 6,835 dollars, and a reinforced concrete flat cost 18,375 dollars excluding the finishing work. From 2000 to 2006, the prices of steel and cement went up by 100%, but the prices of clay building materials increased by only 20%, which means that the prices of the mentioned types of flats are the following:

1. clay flat with an area of 150 m² was 8,400 dollars, excluding finishing work
2. a reinforced concrete flat with an area of 150 m² was 36,750 dollars, excluding finishing work

The question of why there was such a big difference

1. The production costs of building materials and their prices are mainly affected by the prices of the raw materials from which they are produced, the place of production and the transport costs which...
are, in the case of imported raw materials, high. The selection of appropriate local natural raw materials would reduce energy consumption for the production of building materials and would also affects their prices. Local raw materials are easily accessible and do not incur such high transport costs, which can even be 50% of the total costs [7], because the central production of local materials is not required. Construction projects using local materials such as stone, clay and wood have been successful in several Arabic states and did not require high costs for their realization. Also, it was easy to find quality labour in the process of construction.

2. Natural material – local building material – the production costs are low, but the production costs will increase if other imported materials are used such as plaster or steel. The costs will increase most if complex building materials are used such as thermal insulation or multilayer walls. Instead of these materials, which are not produced in Yemen and are always imported, we can use lower-cost local building materials of a higher quality.

3. Imported building materials such as aluminium and plastic materials which are on the market and are used to build blocks of flats might have good qualities such as a long lifetime and easy maintenance, but they have prices even 100% higher in comparison with local building materials [7] such as wood.

4. All building materials imported from other states which do not produce these materials, are even more expensive. It has also been proven that the lifetime of building materials varies, depending on the location where they are used. In order to achieve good economic results, it is important to use an appropriate building material for the particular natural conditions of the building location (e.g., by the sea, external steel structures corrode rapidly).

2 ECONOMIC SOLUTION OF PROJECT DOCUMENTATION

2.1 Dimensions of Constructional Elements

If an architect designs the layout and dimensions of individual constructional elements according to the length and surface of the existing building material, material waste will be reduced and also the unit price will be lower. For example, if doors 2.2 m high and 1.2 m wide are manufactured according to an architectonic design, but on the market, only a wooden board having dimensions 2 m*2.25 m is available, only one door can be manufactured, and there will be waste of the 0.8 m width. The door price would then be higher as if the whole board had been used to manufacture a door of 1.0 m*2.2 m dimensions. If this economic method of design is used, building material waste will be reduced. As a result, the costs for the construction project will also be lower, which sometimes amounts to 5% of the total costs for the construction project. The proof is given by the following example:

It is known that steel is mostly used in construction projects and has a direct impact on the total cost, as reinforced concrete work represents approximately 15% of the cost. Furthermore, steel is the most expensive building material and is imported to Yemen. Its price was 560 D/t in 2005, and it goes up every year due to inflation. The architect must take into consideration the material assortment existing on the market in the layout design. E.g., the dimensions of girders must suit the length of steel which is sold on the market which is only 12 m in length. Therefore, the author investigated, taking into regard this point of view, specific drawings of designed girders according to the executed project documentation of 2002. In this project documentation of a two-storey building with a surface area of 1,166.4 m² and a total cost of 17,937 dollars, the width between the supports was 3.6*5.4 m. The calculation of the girder armature is shown in the following table (No.1) and the layout of the girders is illustrated in figure No.1.

The quantity and cost of the steel loss on reinforced concrete girders are calculated as follows:

a) quantity

1. The B1 girder is divided into B11 and B12, B12 length = 7.2 m. If we know that the steel length is 12 m, then one bar will suffice only for one armature of a B12 girder, and there will be waste.
The quantity of waste will be calculated as: steel length – (B12 length+bend length) = 12 – 7.5 = 4.5 m.
2. The B2 girder is divided into B21 and B22, the B21 length = 3.6 m and B22 length = 5.4 m. In this case one bar will not suffice for three girders of the B2 type, but only for two girders. So there will be waste of the following quantity: steel length – (B22 length + B21 length + connection length + bend length) = 12 – 9.5 = 2.5 m.
3. The B3 girder is divided into B32 and B31, the B31 length = 5.4 m and the B32 length = 7.2 m. In this case B3 is the same as B1, so there will be waste of a length of 4.5 m.
4. The B4 girder is divided into B42 and B41, the B4 lengths are the same as B1 and B3. There will be waste of length 4.5 m.
5. B5 girder is divided into B52 and B51, their lengths are the same as B2, therefore there will be a waste of length of 2.5 m.

The quantity of the armature waste, i.e. the loss of steel on all the reinforced concrete girders, is shown in table No.2. The diameter of the girder armature is 16 mm.

The designed block of flats has two storeys, therefore the total quantity of armature waste is: 2607*2 = 5214 m.

b) price
It is known that the 2005 price of steel was 560 dollars per tonne. The weight of a 16 mm diameter armature is 1.81 kg/m. The total price of the armature waste = 5214 * 1.81 * 0.560 = 5285 D.

<table>
<thead>
<tr>
<th>Girders</th>
<th>Number of girders</th>
<th>Number of armature</th>
<th>Armature waste m</th>
<th>Quantity m</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>19</td>
<td>14</td>
<td>4.5</td>
<td>1197</td>
</tr>
<tr>
<td>B2</td>
<td>8</td>
<td>20</td>
<td>2.5</td>
<td>400</td>
</tr>
<tr>
<td>B3</td>
<td>12</td>
<td>13</td>
<td>4.5</td>
<td>702</td>
</tr>
<tr>
<td>B4</td>
<td>4</td>
<td>11</td>
<td>4.5</td>
<td>198</td>
</tr>
<tr>
<td>B5</td>
<td>4</td>
<td>11</td>
<td>2.5</td>
<td>110</td>
</tr>
<tr>
<td>Total quantity of armature waste in m</td>
<td>2607</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In the above example the author determined that the total price of the armature waste amounted to 7% of the reinforced concrete work, which was 77,854 dollars and represented 3% of the total cost for the construction project. Note: The calculated price is based on the steel loss on girders, which are an integral part of the reinforced concrete work including the reinforced concrete slabs, columns, bearers, foundations, etc.

It follows that the architectonic design must take into consideration the existing dimensions of the building material to achieve a reduction of the presumed loss of 5% of the total costs of a construction project.

2.2 Foundation of Buildings

It is known that the calculation of building foundations is based on a calculation of the live and dead loads of the building and the bearing capacity of subsoil. From an engineering point of view, the same model of foundations must not be used at different construction sites, at which there are usually different foundation conditions. The research proved that there are big differences in costs for the foundations of individual buildings. The execution of foundations which were not dimensioned and designed according to the calculation of loads and the bearing capacity of the subsoil increases the cost of a construction project. The proof is shown by the example of an executed project in 2001. It was a four-storey school building with a total floor area of 1,252 m², the total costs 288,410 dollars. [1]

The building was based on strip foundations. The soil bearing capacity was 1 kg/cm², the precise calculations of loads in accordance with Arab standards brought down the load by 20%, which meant that instead of foundation strips, foundation footings with a lower cost could be used.

The difference in the costs for the foundation strips and footings is shown in table No.3.

Note:

In the above table the calculation of the costs for foundation footings and strips is shown. The calculation is based on the price of 1 m³ of reinforced concrete foundations containing 100 kg of steel, which is 152.2 dollars, while the price of steel is 0.74 dollar/kg. The unit prices of reinforced concrete foundations vary depending on the quantity of steel used. It follows that 1 m³ of foundation footings containing 72 kg steel have a unit price of 131.48 dollars, and the price of 1 m³ of foundation strips containing 127.9 kg of steel is 172.85 dollars. These prices are on the 2001 price level.

In table No.3 it is shown that the cost of reinforced concrete foundation footings is 13,148 dollars, and the cost for foundation strips is 37,733.2 dollars. The difference is 24,588 dollars. The cost for all the reinforced concrete work is 98,581 dollars, and the total cost for the building is 288,410 dollars. This means that using footings instead of strips would reduce the costs for the reinforced concrete work by 24% and the total costs for the building by 8.5%.

The solution of the mentioned example can also be made in a different way, which would be using foundation footings with connecting strips of dimensions of 35 * 100 cm between the footings, which would prevent the sinking of the building. Using footings with connecting strips instead of foundation strips would reduce the costs as shown in the following table:

Table No.4: Costs for a foundation on footings with connecting strips and on foundation strips

<table>
<thead>
<tr>
<th>Foundation type</th>
<th>Footings with connecting strips</th>
<th>Foundation strips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforced concrete</td>
<td>109.16 m³</td>
<td>218.3 m³</td>
</tr>
<tr>
<td>Steel consumption</td>
<td>96.8 kg/m³</td>
<td>127.9 kg/m³</td>
</tr>
<tr>
<td>Costs in dollars</td>
<td>109.16*143.1 = 15,621</td>
<td>218.3*172.85 = 37,733.2</td>
</tr>
</tbody>
</table>

In table No.4 costs for a foundation on footings with connecting strips are calculated, they amount to 15,621 dollars, and the costs for foundation strips are 37,733.2 dollars. The difference is 22,112 dollars, representing 22.4% of the costs for reinforced concrete work and 7.7% of the total costs of the building.

2.3 Time Schedule of a Construction Project

It is known that complex construction project documentation (drawings) requires a longer period of realization than a simple one, which also results in higher costs for the realization. There is some dependence between the construction period and costs for realization.

From a technical point of view the realization of a construction project can be made in a minimum amount of time, but it would mean higher costs due to use of, e.g., modern technologies or more workers, etc. In a normal situation the realization of a construction project is made in an optimum amount of time, which results in...
minimum costs. If the optimum time period of the realization is prolonged, it will cause an increase in, in particular, the overhead, but also probably the direct costs for materials such as steel and cement, the prices of which in Yemen increased from 2000 to 2006 by 100%.

The following example illustrates what effect time has on planning for costs. There was a realization project in 2004 (The Technical Faculty in Yemen), the total cost of which was 13 mil.dollars with a total floor area of 36,178 m² and a planned time for realization of four years.

The author examined what would be the optimum time for realization of the mentioned project which consists of five buildings. CPM method was used along with a sequential problem solution. It was determined that this project could be realized in 3 years and 7 months, which would be shorter by 20 weeks. [3]

It was known that labour and operating costs were 25% of total costs [4], i.e., 3,250,000 dollars. If the weekly labour and operating costs (overheads) were 16,927 dollars, for 20 weeks there could be a saving on costs of 338,540 dollars, i.e., 2.6% of the total cost. This proves that time planning has a remarkable impact on the reduction of costs for a construction project, but in spite of this fact, construction companies in Yemen do not consider time planning important.

Finally it can be said that this article is rather abbreviated, however, the authors tried to clearly express the objective of our research, which is looking for possibilities of total cost reductions for the realization of a construction project. Besides the reasons mentioned in the article, there are also other reasons for increased costs for construction projects such as the price of land, the clear height of a floor and others, which should be solved in the future.

Research Results:
1. Clay houses are approximately 400% cheaper in comparison with reinforced concrete flats. The proof of this fact is the mentioned example of the construction of flats with a surface area of 150 m² in the city of Wadi Hadramout in Yemen in which the price of a clay flat is 8,400 dollars and a reinforced concrete flat is 36,750 dollars, excluding finishing work.
2. In the project documentation (drawings), taking into consideration the existing assortment of material on the market such as steel, the total costs of a construction project were reduced by 3% due to the reinforced concrete girder solution.
3. Foundation footings and footings with connecting strips are more efficient than foundation strips. As a result of using foundation footings instead of strips, 8.5% of the total cost was saved, and using foundation footings with connecting strips instead of foundation strips saved 7.7% of the total cost.
4. By using the CPM method and sequential problem solution in the time planning, about 2.6% of the total cost can be saved.
5. Finally, it can be stated that the total cost of a construction project will be lowered by 16.1% if the project documentation takes into consideration the dimensions of the existing building material available on the market, the actual bearing capacity of the subsoil, and the optimum time for construction is determined.

Recommendation:
The author recommends the appointment of an expert commission to check the project documentation before the tenders for building contractors are invited. The objective is to evaluate the economic aspect of the project documentation.

REFERENCES