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ROLE OF CONCRETE IN SUSTAINABLE DEVELOPMENT IN IRAN

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ABSTRACT

In this paper, some important factors that have significant role in production and utilization of concrete are identified. These factors are analyzed and discussed as the main components that have established the role of concrete in civil, social, economic and cultural development of societies. Some points are raised in older to provide a clear base for sustainable development.

Keywords: concrete, development, properties of concrete, cement, education, research, standards, regulations

1. INTRODUCTION

Thought and efforts of man are two key elements that have the main role in the development process. This process would lead to fruitful results by making use of continuos research and education. Certainly, development enjoys several aspects and characteristics. None of these may be considered as the main factor of development due to the variety of different branches of science and technology. Not to mention, however, that each of these factors has their own specific part in this process.

Development rate may be evaluated by scientific methods in different countries. Evaluation of the extensive field of civil engineering and its several branches, may be considered as one of these methods. Various specialized and up-dated branches of civil engineering, along with other branches of science and technology, provide the main ground for socio-economic and cultural development. Another aspect that should be considered in the development process is that, by means of right thinking, challenge and hard working, it would be possible to convert the natural and potential capacities, to man-made products through industrial cycles.

In today's specialized world, civil engineering branches and their relevant scientific, research and professional activities, in conjunction with environmental engineering branches, fulfil the requirements of man's life in a standard, comprehensive and perfect way.

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One of the most significant aspects that should be considered effectively in the field of civil engineering is investigation on properties of materials and relevant technologies for their production and utilization. Concrete enjoys a specific place amongst other building materials and encounters several problems regarding its production and utilization.

Due to making use of natural resources like sand, gravel and cement as its raw materials, concrete is a main factor for damaging the environment and erosion the natural resources. On the other hand, the impacts of aggressive environment on concrete construction, reduce the service life of concrete structures. All these, form a problem of this complex building material. This specific character of concrete, strongly influences economic circumstances.

Therefore, optimization of concrete as a structural material has an important role in engineering economics. Another critical point is that a great number of different professions in industries influence concrete production and utilization, directly and indirectly.

2. CONCRETE; FROM PRODUCTION TO UTILIZATION

Although the basic concrete materials consist of cement, aggregates and mixing water, but addition of some other materials is required for development of special types. The purpose of this paper is not an analytical approach to engineering, physical and chemical properties of concrete or the interaction between concrete constituents, but it is oriented towards notification of the fact, that firstly the concrete materials as simple elements have their own specific characteristics and secondly, as a composite material concrete chemical reactions, at the time of setting, after hardening, and at the time of utilization, leave special effects. Therefore, those who are somehow involved in professions related to production of concrete constituents or their composition as the end product (concrete) should focus on the basis of appropriate research about different aspects and dimensions of this complex material.

Concrete materials consist of cement, natural and artificial aggregates, natural and artificial fibres, polymer materials, admixtures (natural and artificial pozzalanas), additives (plasticizers, super- plasticizers, accelerators, expansion materials).

Interaction of chemical industries, however, implies a logical and continuous interaction between concrete and other substances. Considering the production of different types of concrete, the following types may be put forward:

- Prefabricated concrete
- Prestressed concrete (Pretensioned, post-tensioned)
- Ready mix concrete
- Lightweight concrete
- Insultion concrete
- Special concrete
- Roller compacted concrete
- Heavyweight concrete

- Shotcrete
- Preplaced concrete

More accuracy and care in production, utilization and different levels of technological trends would resolve many problems. For instance employment opportunities will be provided, construction methods will be improved, construction rate will be accelerated and therefore necessary ground for development will be provided.

Among the concrete constituents, cement has a more dominant situation. Cement is usually regarded as the symbol of industrial productivity and by some others, the cement consumption is considered as the motivator of economic wheels. Cement consumption per capita is also regarded as an index for development, These two views are somehow correct and the significant evidence for development.

Production rate of hydraulic cement in the world, in 1999 has been 1.52 billion tons. 15 countries possess 70% of the whole product of this type of cement accordingly, and the remaining 30% belongs to the other countries of the world. The 15 countries are listed below:

1. China	6. Brazil	11. Mexico
2. Japan	7. Germany	12. Russia
3. U.S.A	8. Turkey	13. Indonesia
4. India	9. Italy	14. Taiwan
5. South Korea	10. Spain	15. Thailand

If the export and import rate is added and deducted to the production rate, respectively then the rate of cement consumption in every country is obtained. By dividing this figure to the population of each country, the obtained figure is the cement per capita consumption, which is regarded as a relative index of constructiveness. Table 1 shows the production, consumption, and per capita consumption of cement in some countries, in the year 2000 [1].

As may be seen from table 1, Iran is situated at the lowest rate. This table may be regarded as a comparing tool for measurement of development from quantitative point of view. Based on an other view, according to the quantitative objective of the Third Development Plan (TDP), [2] it is predicted that the household density would reduce from 1.61 in 1999 to 1.12 in 2004, which is the termination year of the TDP. It means that 3.114 million residential units, will be constructed, 216000 units in urban and 954000 in rural arrears. In total, 13 million households will reside in these units. According to the implemented studies, the required cement for residential units, considering various types of structures and the methods for construction is more than 43 million tons. Assuming that the average production rate of cement per year has a constant growth, it is required that in the TDP, 8.6 million tons of cement should be consumed, merely for construction of residential units.

In case it is supposed that the cement consumption is only allocated to civil engineering activities, now we have to determine the cement quantity for other types of civil works. For determination of this amount, we may use the cement consumption rate in housing sector, to the total amount of consumed cement in the country, in the Second Development Plan (SDP).

According to the data and statistics published by the Central Bank [3], Management and Planning Organization [4-7], National Land and Housing Organization and the Statistical Center

of Iran, the average cost of per m^2 of residential units in urban areas, built by the private sector and started in 1999 which is the termination year of the SDP, was 467,808 and the average cost within the period of the Second Development Plan was estimated as 358,238 Rls. These costs for the completed buildings at the end of 1999 was 459,676 Rls. and its average rate was estimated as 295,997 Rls. within the period of the Second Development Plan. Provided that the figure 358,238 Rls. is assumed as the base for estimation calculations in the TDP, and if the average growth rate in the SDP is considered for the TDP, the estimated average cost for per m^2 of buildings would be 551,684 Rls. Undoubtedly, this figure is quite conservative and underestimated.

Based on the inaccurate information and the implemented studies, also taking into consideration the experts approaches, if the cost of per m^2 of a rural residential unit is assumed as 50% of an urban residential unit, (this rate must be about 60-70 %, actually) the expenditure for per m^2 of rural units will be 275843 Rls. The average surface area in urban and rural residential units to be built in TDP period, are 216000 m^2 and 76320 m^2, respectively provided that the average surface area per urban and residential unit is considered as 100 and 80 m^2 respectively. By these calculations, the sum of 140,216 billion Rls. would be required for construction of 3.114 million of residential units. Subject to the mentioned reference it is determined that the ratio of spent credits for production of residential units, to the total spent credits within the Second Development Plan, which is 94465 billion Rls. and 101.21 billion Rls., respectively, is equal to 0.95.

Now with the assumption that this ratio within the whole 5-year period of the TDP is constant, the expenditures of other civil projects will be estimated by having the cost of residential units in this period, which is calculated as 147,600 billion Rls. Thus the proportion of construction projects in the TDP will be 51.3 %. Therefore, the required amount of cement will be estimated as 88.30 million tons, which results in total, the consumption of 131.3 million tons of cement during the TDP. It means that 26.26 million tons of cement will be required per year. By calculating the 1.04 ratio of production to consumption within the SDP, the average production of cement within the TDP would reach 136.56 million tons, meaning that the annual cement production rate must be 27.513 million tons.

It is now clear that for fulfilment of the TDP, so many efforts should be made for production of cement and consequently concrete, and relevant industries.

3. CONCRETE AND CLIMATIC CONDITIONS

Since concrete as a structural material should be durable and possesses the expected service life and the required durability in the specific environmental conditions, Therefore it is required that the environmental circumstances which may influence the strength gaining process and its texture, must be taken into consideration. Application of appropriate construction details, addition of other materials to protect concrete and concrete structures and accessibility to an optimum mix design, all are of great importance. For our country with 5 variable climatic conditions, it is necessary to use national regulations, standards and recommendations rather than requlations of other countries that may not be compatible. It is therefore necessary to provide the codes of practice, standards etc. for the mix design and other aspects of concrete

independently, taking into account the specific climatic conditions of different areas. This requires great and realistic challenges.

Amongst the various climatic conditions, Persian Gulf coastal regions as well as northern coastal areas of the Caspian sea are the most critical areas, since these areas may be considered as the gates of development. Construction of super structures must be based on the required durability and strength, as these structures are directly related to the topic of development.

4. CONCRETE AND EARTHQUAKES

One of the most severe and critical issues in our country is seismicity and the frequent occurrence of severe earthquakes. Other natural disasters like floods, landslides etc. are also obstacles of sustainable development in our country. A short review of the earthquake issue makes it clear that a large number of research and executive undertakings for an appropriate programming regarding earthquake and how to approach its related problems, e.g. strengthening of existent buildings, as well as provision of a comprehensive plan for disaster management in Iran are all left unattained.

In a country that every 5 to 10 years an earthquake with the magnitude 7, or every 2 to year an earthquake with magnitude 6.5, occurs it is certainly necessary to consider earthquakes, and strengthening of buildings against them in long-term development plans and budgeting programs, very strongly and significantly. Undoubtedly development of the country would not be fulfilled without concrete utilization and the relationship between concrete and earthquake engineering should be maintained through continuous research and educational programs.

One of the significant cases which is to be deliberated is the concrete behaviour in earthquakes regions. In other words, the seismic behaviour and determination of specifications of the concrete, which can absorb the vibrations of earthquakes to an acceptable limit, all, require their own specific software and hardware facilities. Provision and making of required equipment will involve a great number of industrial units. It is quite obvious that a great number of research studies should be implemented on all aspects of concrete structures as related to earthquakes, and many developmental activities are required to do these research studies:

On the other hand, since the production of concrete is not mechanized, like production of steel, several factors interfere in its production and utilization. If these factors are determined through accurate scientific research processes, one of the development steps has been taken. It is interesting to know that during the 5-year, SDP, 6 severe earthquakes with 6.1-7.5 magnitude were taken place. Therefore, prediction of such events in the TDP is vital

5. CONCRETE AND STANDARDS

There is no need for reasoning that one of the significant factors for progress and development is use of standards and regulations in all activities. As regarded concrete, not only provision and application of standards is a necessary action for achieving the sustainable development, but it should also be taken into consideration that the standards up dating, by means of continuos scientific research is vital.

Ever since, in many countries, numerous standards have been provided for concrete, its materials, constituents and special types, even on concrete structural design, and analysis. The followings have to be mentioned, regarding the situation of concrete standard in our country:

• Iranian Concrete Code of Practice (ABA)

This code of practice has referred to 130 codes excerpted from 110 ASTM, 23 BS, 21 AASHTO and 44 other standards. The interesting point is that only 29 Iranian standards have been quoted [8].

• National Standards (ISIRI)

Yet, 62 Iranian standards have been compiled on concrete, cement and aggregates, amongst which only 6 standards on Portland cement are mandatory. Standard 3132 entitled "hot rolled reinforcement bars in concrete" is one of them. Among 29 National Standards, only 16 titles have been compiled since 1986. Generally, 45 standards have been provided or revised in 1990-2000. Another 14 standards in the field of concrete are under preparation and publication.

6. CONCRETE; EDUCATION, AND RESEARCH

Development is not feasible without considering its required components. Is it possible to compare these components, to each other, or, consider more significance for one of them, for instance manpower? Undoubtedly, manpower is the main requirement for sustainable development. Efficient manpower needs education and research. Regardless of priority of research and education, vice versa, or their interaction within a specific process, it is important to know that research provides the suitable ground for growth and innovation. Some of the development indices were reviewed, in the past sections of this paper and now some facts on the financial credits for research and education are put forward.

6.1 Education

According to the information obtained from the data-base of Scientific Information and Documentation Center, affiliated to the Iranian Ministry of Science, Research and Technology, 59379 titles of Ph.D. and MSC dissertations have been done since 1989. This figure may be less than actual, but since these dissertations are related to all of the branches of science, and majority of unregistered dissertations in that Center are those of medical science (and therefore not included in the above-mentioned information), thus, this figure may somehow be acceptable for the present survey.

The total number of Ph.D. and M.Sc. dissertations in the field of civil engineering is 1314, amongst which 114 titles (%8.7) are directly related to concrete, 178 titles to steel (%13.5) and the rest, to other subjects.

The number of dissertations on concrete is not considerable. It is therefore obvious that higher education as well as professional education bodies should pay more attention to such fields like building materials especially concrete.

6.2 Research Credits

In the TDP[1] it has been predicted that at the end of this period, proportion of the spent credits in the field of research, to the Gross Domestic Product (GDP) in public sector (Government) should reach 1 % of the total credits and in the private sector to 0.50 % of the whole credit of the private sector, governmental companies and banks.

In the same plan, the government is obliged to spend 15 % of this credit in implementation of fundamental research works, as well as research studies, which would lead to new technological trends. Such an approach and orientation in the TDP is quite entrusting. Based on the commitments of the SDP, the fulfillment of the TDP would be planned.

In table 4, the final expenditures of the year 1999, is estimated on the basis of the rate of average definite expenditures to approved expenditures [2]. Therefore, the definite expenditures for civil construction within the SDP are given in this table. If the rate of these expenditures is considered as one of the development indices, it would be seen that the proportion of the total research credits, to the Gross National Income (GNI) in the SDP was about 0.3 %, and this occurred in circumstances where the objective was achieving 0.75% of the public budget and 0.75 % of the "Other resources" budget, in the SDP.

Reference to table 4 , makes it clear that the proportion of research credits. to the total budget in the SDP was about 0.46 %, and its proportion to the construction credits was 4.57 %.

Knowing about the figures of expenses and credits of housing, urban and rural development research, it would be more clear that the proportion of this item to Gross National Income, Total National Budget and construction credits, is not satisfactory. The interesting point in this relation is the proportion of research credits to actual construction activities, which is 0.06 %. In other words, for every 10000 Rls. allocated to construction activities, only 60 Rls. is spent for research works in the same field.

One of the figures which is not reflected in the table is the proportion of credits of university, industrial and technical research (in the field of urban and rural development) to the total national credit, that is 0.33 %. This figure also shows the inadequacy of credits in this field. Other view to the period subject of concrete and development indicates that within SDP, 114.52 million tons of cement has been produced. Assuming that 80 % of this amount is used for making different types of concrete of average 250 kg/m^3 cement content, therefore 293.200 m^3 concrete has been used.

If the cost of per m^3 average, is 100,000 Rls., the production value of this amount of concrete is more than 29317 billion Rls. The proportion of total spent credits for research works in the field of housing, urban and rural development during the SDP (which is 55454 million Rls.) to the cost of only one of the building materials (concrete), has been about 0.2%. In these calculations, if other materials and activities are included, this percent will seriously reduce. These calculations necessitate more accurate programs for construction activities of the country.

[1]Third Development Plan

7. CONCRETE AND QUALITY CONTROL

The quality issue has two specific aspects; quality management and quality control. Generally speaking, quality control is a strategic process, with the main objective of stabilization of constructional development, by means of error prevention.

Since the properties of concrete are gained during specific period of time and under certain environmental conditions, therefore the quality control process will be quite significant. Some of the manufactured products have more satisfactory quality control procedures, but some other materials like concrete has different conditions. Although the quality control of cement and other raw materials are done in quite satisfactory circumstances, but it should not be forgotten that small changes in one of its properties, may influence the concrete workability. Therefore special care should be made regarding the quality control of cement.

Mixing, transportation, compacting, curing and concreting are the main processes that greatly influence the quality of concrete.

8. CONCLUSION

Some important points are raised having significant role in the production and utilisation of concrete. These factors are analyzed and discussed.

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