CODES FOR CONCRETE DESIGN AND CONSTRUCTION IN NEPAL

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Abstract:

This is a paper dedicated towards the state-of-the-art of concrete design and construction practices in Nepal. Some of the aspects related to materials, existing status of codal provisions and their implications have been studied. The paper also reflects the need of research and development involving potential in-house stakeholders together with international linkages in order to develop and improve concrete design and construction practices in the country.

1. Introduction

Nepal is a country with typical geographical feature characterized by the variations in altitude by more than 8000 m within a stretch of about120 km south to north. The country possesses unique topography and climates with potentials of natural resources, agricultural products as well as different types of flora and fauna in wide varieties. Agriculture as well as natural resource based industries and tourism are the major areas to be explored for economical growth towards its prosperity. This is possible only through the establishment of networks of infrastructures as basic requirements.

Concrete is the main construction material in Nepal for its infrastructure development. The basic raw materials – aggregate and sand required for its production are easily available in all parts of the country – the widely spread aggregate being sand stone. The in-house production of cement fulfills only about 25 to 30 percent of its total demand. The rest of the cement is imported from abroad. However, the potential for the establishment of new cement factories in the country, as studied by different agencies, is quite high.

Standardization in design and quality control of materials for concrete construction in Nepal is still at its tender age. Nepal Bureau of Standards and Metrology (NBSM) as a government body was established in 1988 to work as a secretariat to Nepal Council for Standards (NCS). NCS was formed in 1980 under the "Nepal Standard (Certification Mark) Act. However, these organizations so far have been able to concentrate on very limited areas of the issues. NBSM has been expanding its relations with concerned national and international institutions to develop and improve its capability to prepare standards and codes for concrete design and construction in the country. Nevertheless, it has to go a long way to develop the national norms and standards on various fields in general, and concrete design and construction in particular.

2. Materials for Concrete Production & their Standardization

Brief information about the materials in relation to the concrete design and construction practices in Nepal are presented here.

2.1 Cement

Almost all of the existing cement factories in Nepal produce ordinary Portland cement. Imported cements also are mostly Portland cement with different grades. One of the cement factories in the country (Hetauda cement factory) began to manufacture and market Portland slag cement since the last 5-6 years.

NCS has already laid down norms for chemical and physical requirements for ordinary Portland cement through NS 49-2041. Some of the manufacturers produce cement as per NS 49-2041, nearly the same as per Indian Standard for ordinary Portland cement while some others follow DIN. It has been observed that cement from one factory to another in Nepal has significant range of variation in properties especially in the kinetics of strength though all of them produce ordinary Portland cement.

The present practice in most of the construction works in Nepal is the use of the same type of cement almost for all purposes irrespective of types of structures and conditions of construction. With the diversity of construction activities ranging from simple residential to large structures, and to be constructed under different conditions of construction, the need for use of different grades of cements and also of special cement is strongly felt. In recent years cements other than Portland cement (i.e. slag cement, pozzolana cement, expansive cement and others) are also used in different constructions. But their uses are very limited. These cements are imported from India and other countries.

Based on the data of 1997 – 1998 studied by the Department of Mines and Geology it is observed that about 25 to 30 percent of the total demand of cement is produced in the country, whereas about 70 - 75 percent of it is imported from elsewhere. In the same study the total consumption of cement in 1990-1991 has been identified as 626 thousand metric tons and with an annual rate of increment by 10 percent the demand in 2004/2005 has been projected as 2,377 thousand metric tons. Most of the shortfall is fulfilled from India. Similarly, in projects, which are handled by the donors, most of the materials including cement, are directly procured by themselves from abroad.

2.2 Sand

NCS, from the view point of concrete construction, has not yet categorized and standardized the sands available in various parts of the country. However, in most of the construction practices it is categorized in a similar way as in the case of Indian and British standards. Based on such categorization sand in the hilly areas of the country lie in the I grading zone, in valleys of the hills – II grading zone and in Terai – III and IV grading zones.

2.3 Aggregate

Coarse aggregates are the widely available construction materials in Nepal. In order to identify the various mechanical properties of aggregates at river beds throughout the country a study was conducted by the Department of Roads. Various mechanical properties such as Aggregate Crushing Value, Aggregate Abrasion Value, Aggregate Impact Value etc. have been identified for those aggregates. Most of the aggregates available in the river banks and beds are sandstones. The other types of aggregates used but in small quantities are limestone and marble stone aggregates.

2.4 Admixtures

In recent days there are some practices in Nepal to use admixtures in concrete. Mineral admixtures in the form of fly ash and silica fume are used in major projects handled by international consultants and contractors. Chemical admixtures to some extent are also recommended and used by the local consultants and contractors. About ten private organizations are involved in the country to supply various types of chemical admixtures. The quantity of materials, most of them supply, range from 100 to 150 tons per year with different brand names. Some of the suppliers at times have supplied even up to 2 to 3 thousands tons of chemical admixtures. Data about the total consumption of chemical admixtures in concrete are still not available in the country. It is because not only the suppliers import such products but the donors in particular projects also procure and such data are not easily traceable. However, the trend of use of the admixtures in concrete is thriving.

2.5 Steel

Steel in the form of iron rods, used in concrete design and construction are produced in Nepal. The year wise production of iron rods and angles is presented in Fig. 1. The demand of reinforcing steel in the country in 2002 is in the range of 200 thousand metric tones, whereas its production in the same year is in the range of 155 thousands metric tones. Most of the reinforcing steel produced in the country are High Tensile steel with yield stress up to 550 MPa. These are Cold Twisted Deformed (CTD) and Thermo Mechanically Treated (TMT) bars. Very high tensile steels used for prestressing purposes as well as for suspension cable are not yet produced in the country.

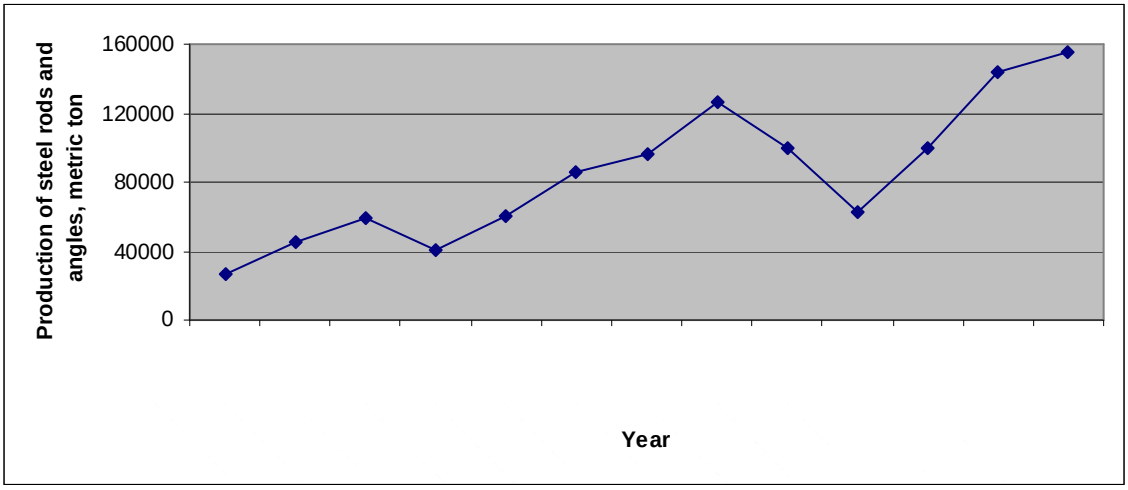

Fig. 1: Production of Steel rods and angles (source: industrial statistics FY 2002/2003)

3. Design and Construction System and Activities

Professional organizations such as consultants and contractors are actively involved in design and construction industries at the national level in recent years. Most of the consultants and contractors companies are of private initiatives. Very limited number of consultants and contractors under government ownership are also functioning in the country. But their activities are very modest and capabilities are also limited.

There are more than 100 consulting firms actively involved in different design works. Similarly, contractors are classified as class – A, class - B, class – C and D class. There are about 150

contractors in class A as lead construction companies. International consultants and contractors are also engaged in Nepal.

4. Existing Codal Provisions for Concrete Design and Construction

In the design and construction activities in most of the major projects in Nepal donors are involved. Similarly, due to the lack of Nepal's own national codes and standards, the donor agencies use their own standards as per their convenience. National Building Code is under preparation with the involvement of NBSM. But the activities are so slow that after more than 20 years of the establishment of NBSM very limited number of documents have been produced. A document related to National Building Code of Nepal was prepared in the beginning of 90s with the involvement of a team of national and international consultants. The document consists of about 20 different sub areas related to the design. But most of them are not yet reviewed and endorsed by the NCS and the design community at large in the country still does not follow these standards. In recent years only one of the fifty - eight Municipalities is actively involved in implementing these document for design works of buildings and other infrastructures. In connection to the testing of materials on concrete construction NBSM's activities so far are concentrated to only cement testing. The various test parameters adopted for cement are chemical composition (oxide composition), physical properties and compressive strength. With regard to the testing of sand and aggregates no standards have been developed by the NBSM. Similarly, national standards and code of practices about the use of different types of available admixtures in the market still do not exist in Nepal.

Limited activities of NBSM and other government and private organizations involved in design and construction works has not yet been able to establish a consensus to develop and use a particular code for concrete design and construction in Nepal. The donor agencies also use their own standards of design and construction practices as per their convenience. Various departments: Department of roads (DOR), Department of Housing and Physical Planning (DHPP), Department of Irrigation (DOI) and others specify standards to carry out concrete design works according to their own. There seems no coordination as yet among these departments to identify and specify a unified approach of design and construction, however, all of them are government bodies. Notwithstanding the freedom of using any codes, most of the relevant organizations involved in the construction industries in the country adopt Indian Codes and Standards. In the second preference come British and American standards.

5. Implications of Using Various Codes

The capacity of structures designed and constructed using different codes of practice is obviously not the same. In this regard some research studies were conducted in Kathmandu in the Institute of Engineering, Tribhuvan University. One of the studies in this connection was conducted to identify the capacity of different bridges lying in a highway of about 500 km in length. Different sectors of highway within this length were designed and constructed by five different donor countries: Canada, UK, India, Russia and China. Results in terms of the capacity of bridges built in those sectors of highway are presented in Fig. 1. Data presented in the figure show that the capacity of the bridges designed and constructed by separate donor countries using their own codes vary by about 50%. This was not desirable because the same types of vehicles are plying on those road sectors. From these data it can be observed that either some of the bridges are uneconomical or some others are under-designed.

Another study was conducted to identify the capacity of reinforced concrete beams of framed building using different codes. Up to thirteen different codes were compared on various parameters.

Large variation has been observed from code to code in bending and shear capacities of the beam section. For example, the variation with respect to the grade of concrete is very large in AASHTO and USSR codes and ranges from 3 MPa to 11.5 MPa for concrete grade from M15 to M65. Similarly, the area of tensile reinforcement for the same service load and beam section with M20 concrete vary by more than 50 percent. This is presented in Fig. 3.

6. Concrete Production and Quality Control

Concrete production process has not yet been industrialized in Nepal and no factories have been established to produce ready-mixed concrete. In recent years some efforts are being made basically from private initiatives for prefabrication, unification and standardization of some of the structural elements. Production of prestressed electric poles, prestressed hollow slabs, reinforced light-weight concrete panels, paving and wall blocks are some of the examples. However, these products have not yet been standardized by NBSM. Similarly, they have not yet received good acceptance in construction industries and therefore produced in a very small quantities and majority of the construction projects in the country produce concrete as per their own construction requirements.

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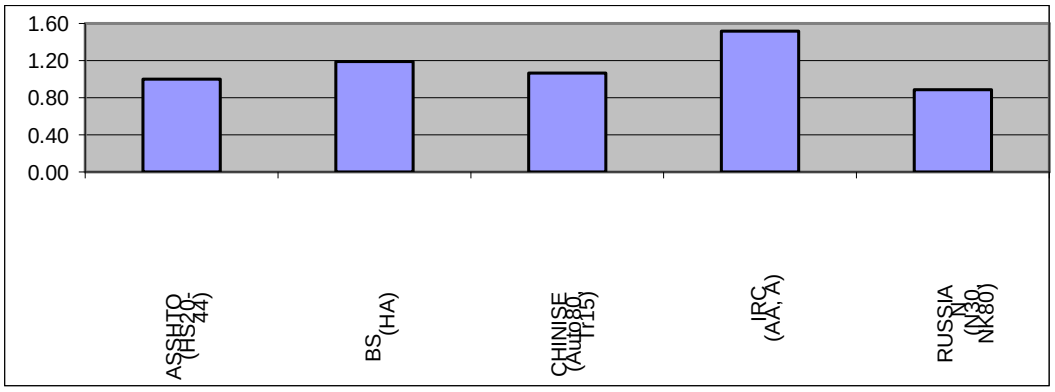

Fig. 1: Relative Bridge capacity in the same highway (Length ≈ 500 Km)

The widely used grade of concrete produced in Nepal is normal strength concrete, which in its characteristic strength range from 20 to 40 MPa. Among them M20 and M25 are the most common. In particular cases as well as in research studies at the Institute of Engineering (IOE) concrete of grade higher than M60 has also been produced in lab conditions.

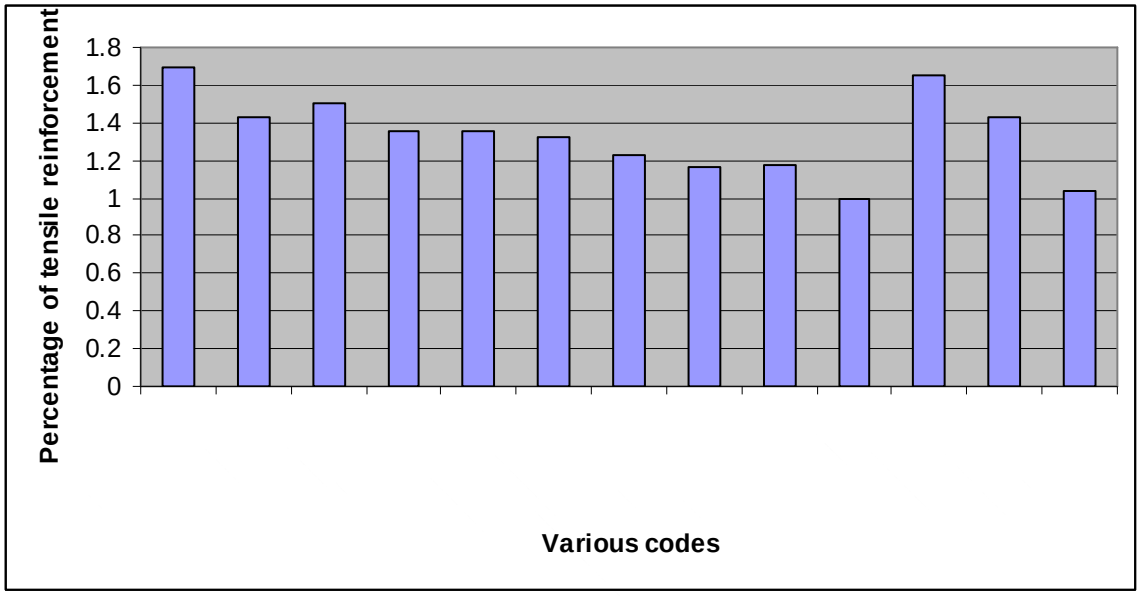

Fig. 3: Percentage of tensile reinforcement in a beam of the same cross-section and service load with respect to various codes (source: M. Sc. Thesis, IOE, Pulchowk)

Almost all of the concrete in most of the construction works with the involvement of local consultants and contractors are produced by Nominal Mix approach. This is because most of the engineers involved in the construction work do not have the idea about the state–of-the-art of concrete mix design. Moreover, concerned engineering community still does not seem particular towards the approach of concrete as construction material. One of the reasons behind this may be because of the absence of the concrete technology course in most of the bachelor of civil engineering syllabi. And those with higher academic degrees in civil engineering with the knowledge in concrete technology are limited in the country. Similarly, refresher courses for industries in this area are also very limited. Recently the engineering colleges under different universities in the country have incorporated course on concrete technology and this will likely change the situation in concrete production approach in the country in near future.

Most of the manpower involved in the concrete construction industries in Nepal is seasonal. Mostly peasants during the off-harvest time are involved in constructions in local levels. They have not received appropriate skill and know-how as to how to behave with concrete during mixing, placing and compaction. Some of the academic institutions like IOE, Council for Technical Education and Vocational Training (CTEVT) and other private academic institutions started trade and skill training courses. But these programs are conducted only occasionally and are very limited.

In Nepal, the construction labour market is relatively cheap. Similarly, in general, constructions handled by the local consultants and contractors are not very huge. This has led to the use of local manpower rather than using system of construction equipments. However, mixtures, cranes, hoists, conveyor belts are used by some of the national contactors and prefabricators. Use of such and more sophisticated construction equipments are used by the international contractors within the country.

Statistical approach of quality evaluation of concrete constituents and concrete itself as end product is rare in most of the constructions projects handled by local consultants and contractors in Nepal. Limitations on various parameters such as different impurities in sand and aggregates, variations in other physical, mechanical and chemical properties to some extent are specified in the relevant specifications. However, no exercises are being made through statistical approach to evaluate the quality. The basic parameters regarding the quality control of concrete production as end product is

also based on its average compressive strength rather than characteristic compressive strengths. Moreover, tensile strength tests are not specified to be conducted in most of the specifications. So far we have not been able to identify the average standard deviation of concrete strength of different grades for our class - A contractors.

8. Research and Development Activities

Research and development activities in concrete design and construction works in Nepal are at a very initial stage. Stakeholder organizations such as various government Departments and Municipalities, academic institutions, NGOs and INGOs, associations and professional organizations NBSM and others are needed to be mobilized for its initiation, development and improvements. Among them, some of the individual organizations as well as academic institutions in public and private sectors are undertaking some research activities. Academic institutions are undertaking these activities through their advanced academic programs such as masters and Ph. D. initiatives. However, the information dissemination through trainings, seminars and short courses needed to enhance R & D activities is at very low level.

Government organizations having larger percentage of budget in infrastructure development carry out the design and construction works through various consultants and contractors in a traditional way. Similarly, no sustainable joint R and D activities are observed between academic institutions and various government and non-governmental organizations, consultants and contractors in relation to the enhancement of design and construction works.

R & D activities to produce and use high strength and high performance concrete is strongly felt in Nepal to incorporate prestressed concrete structures particularly in concrete bridges. This is also essential to economize the overall construction cost as studied by various investigators. Similarly, another area of use of high strength and high performance concrete is the hydropower structures, with large amount of concrete consumption. Due to the use of low grade concrete most of the head regulating structure of the hydro-power projects in Nepal have been severely damaged in a relatively very short period of exploitation.

However the international expert panel recommended to use M40 concrete in the head regulating structures in the KaliGandaki project, this was damaged within six months of its use. The reason may be that the recommendation did not consider the typical characteristics and size of debris (boulders) and their impact forces in the rivers with practically no catchment control in Nepal. A research study in this regard was conducted at IOE considering the impact forces of boulders. It has been identified from the investigation that the grade of concrete required for the head regulatory structure depends mainly upon the boulder size. It has been identified that for boulder sizes of 250, 500 and 750 mm in diameter the grade of concrete required is M60, M70 and M80 for a return period of 80 years. Further studies are necessary and may be materialized in an internationally coordinated manner to arrive at more reliable result as this seems to be a problem not only for Nepal but for other countries as well.

Role of the government in the beginning would be sufficient in determining and formulating the overall rules and regulations to initiate R & D activities in various institutions and organizations through individual as well as collaborative efforts. This is one of the areas of immediate intervention by the government. Share of international experience and knowledge through various forums would be very much helpful to initiate such undertakings in public and private sectors in the country.

9. Role of Asian Concrete Forum

Nepal has not yet been able to develop various fora in sharing knowledge and experiences in enhancing the concrete design and construction works. Academic institutions in public and private sectors so far have been able to concentrate on their routine classroom activities only. Research and development activities in this area are very limited. Professional organizations, such as Nepal Engineers Association (NEA) in its present form will not be able to address this particular problem. Recently Structural Engineers Association, Nepal (SEANep) has been established. This organization, to some extent, will be able to focus on concrete design and construction issues. However, the material and technology part will likely be untouched even with this professional organization. At a level of professional society this area could be properly addressed only by establishing forum such as Nepal Concrete Institute (NCI). Effort to this direction is underway recently. This professional organization will be able to establish links among stakeholder institutions in the country and relevant organization in the world and would play facilitating role to create various fora in developing and enhancing the quality of concrete design and construction. Asian Concrete Forum (ACF), in this regard, can play a very vital role in supporting such activities.

10. Conclusion

Concrete design and construction in Nepal is one of the major issues for the development of infrastructure as a basic requirement towards its prosperity. The country so far has not been able to standardize the concrete design and construction practices. This has led to the use of various codes and standards, which sometimes differ by more than 50 percent on some parameters. Recently, some efforts are seen from the government as well as from various academic institutions and professional organization to address the concrete design and construction problems in the country. Establishment of Nepal Concrete Institute is one of the efforts to this direction. These efforts, in the present global context, are not sufficient only with the activities within the county. An international network is needed to efficiently manage this problem in an effective manner. Active in-house action programs by Nepal Concrete Institute and involvement of this Institute in Asian Concrete Forum, will be one of the effective steps to this direction.

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