Synergic Aspects of Traditional Indian Construction

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INDIAN construction dates back to centuries from the days of Mohenjadaro and many of these constructions have withstood the test of time and different types of calamities – natural or man-made. The focus of this paper is to discuss the genesis of traditional Indian construction approach and present the synergic aspects, which form the basis of the inherent strength to withstand environmental loadings. Citing examples of a temple in Tanjavur, community hall in Madurai and the recent Valluavar statue in Kanyakumari, it is suggested that a blend of traditional with modern construction approach will provide the necessary Indian dimension in construction. Engineering aspects of traditional construction are also discussed to assess the merits in materials used and technology adopted.

Introduction

Construction activity today in India is a mix of traditional and modern construction aspects with predominance of western influence in materials and technology used for construction. Concrete which occupies nearly 80% of construction activities in India is evolving in the same manner as in developed countries from normal Portland cement concrete – PCC- to reinforced cement concrete – RCC- with high strength steel bars to improve bond, and then onto high performance concrete – HPC – with durable eco-friendly and performance enhancing admixtures and composites. But if one looks back at Indian tradition in construction, which is more than 5000 year old with different construction activities ranging from dwellings to roads, bridges, large community halls and places of worship called temples or mosques and after the arrival of Vasco de Gama, churches. With such a large amount of input in the construction activity – proofs are the monumental structures still standing as landmarks reflective of Indian culture – it is only appropriate to look into this input and combine with the modern approach so that a 'best-of-both-worlds' result could be obtained. The purpose of the present paper is to focus on some aspects of traditional construction and link with those in modern technology so that a blend of Indian construction is obtained. The emergence of Vaastu Saastra in recent times shows clearly that there are features in traditional construction that can supplement present day approaches very well. Unfortunately this is only the tip of an iceberg and when one starts looking more "inward" into traditional construction there are many issues to be addressed. As such much of the data and information available in different forms from written texts in walls to practices which have oral communication basis only, are still to be data-mined, and it is proposed in this paper to highlight some of them, which can augment or supplement present day practices.

Basis of Construction Technology

It is interesting to look at the genesis of construction technology. Modern construction mostly caters to function or utility, economy, safety and distinction as a landmark structure in the order of priority. The recent high-rise residential buildings, cable-stayed bridges, towers, aircraft hangers and pavilions are examples demonstrating why, what and how of construction technology. Similarly materials like concrete, composites, high-strength steel, aluminium, stainless steel and metal alloys have all become part of construction technology with choice being optimized for economy and performance. But if one looks at traditional approach there is a major difference in that the human mind had played a major role than the consideration of utility or economy or even safety. In traditional approach the motivation for construction had been an evolutionary process. It gradually evolved from one of building a shelter against nature's fury to that for social and cultural meetings of the society through roads and community halls and then onto structures that satisfy the spiritual

needs, like temples, even though they are "assumed to house God". Here is the major deviation in the fundamental approach to construction and this only rendered material choice based on availability. Rock and clay with lime and other organic glues like 'vajjiram', egg-yolk and jaggery formed the main materials. Fig.1 gives some of the salient features of both approaches. On the left of the Fig.1 a typical structure conforming to traditional form is shown along with some of the features like spiritual reflecting mind over matter, available materials-not synthetic-, human labor being the predominant form of execution of construction process with no mechanization, creativity reflecting the mind's urge for doing new and different and a system which will be life long. Whereas modern construction as shown on the right of Fig.1 with a high rise building, has entirely different features like function/utility, mostly synthetic materials, use of machinery with labor and a system reflecting some distinction of an individual's concept and short life span of 30 to 50 years. This is only to bring out the motivation in both construction approaches. It is said that

- Roman construction is intellectual;
- French construction is emotional;
- Italian construction is of renaissance;
- British construction is catholic;
- American construction is open and brash and
- Indian construction is of the mind or spiritual!!

Hence the features of Indian traditional construction need to be looked at from 'within' and also from outside!!! The 'looking within' part is the most significant feature as it caters to the human beings and their surrounding environment and forms the basis of construction and here only the difference comes from the other technology practices. This aspect if integrated with present day approaches in construction will provide a synergic and harmonious dimension to the construction and will enable the structure to 'live' in variations in environment without much distress. The next part gives an idea of this basis,

* Spiritual	*	Functional
* Available Material	*	Synthetic Material
* Labor	*	Labor-m/c
* Creativity	*	Economy
* Life-long	*	Limited life

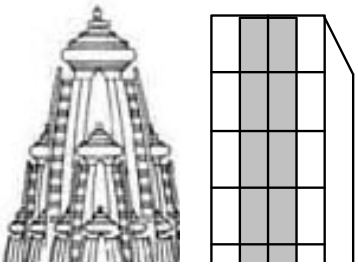

Fig.1: Features of Construction

Basis of Indian traditional construction

In Indian traditional construction, association with the mind and spiritual interests of the humans formed the basis and that is why the science-it is treated as science and not technology- of construction called Vaastu Saastra is based on space-energy principles. Hence all constructions are

designed to be 'living organisms' and the role of 'vimana' and 'gopura' forming parts of most traditional constructions is mainly to reflect the different parts of living organisms with sanctum-sanctorium-'garba-gruha'- housing the 'aatman' or life. In addition, a new dimension to incorporate the sound and light aspects was added so that all constructions have the sacred geometry combining rhythm (sound) and form (light) and the link with present day acoustic emission studies on materials can be easily seen. This also had been the motivation to use materials that 'breathe' and rocks and stones of different types, clay, lime and other organic materials were taken to have this property.

Forms of Indian traditional construction

Since the basis of Indian traditional construction is the living organism, evolution of different forms had some relation with the cosmic space which was considered to be the source of all living organisms. So the form had the underlying principle

> *If a part of the vast space is isolated and bounded by four walled system called 'building', then a portion of the cosmic space is trapped and becomes a living organism, which starts 'breathing' like a human being and this breath or energy waves was supposed to affect living beings visiting the building in a positive way.*

An extension this principle is brought out as a methodology in Vaastu Saastra to bring harmony between human and environmental vibrations. So the forms of Indian traditional construction always reflected varied forms of humans depending on the regional culture. Fig.2 gives this aspect with the human form on one side. Regional variations depict creativity with the overall concept still retained. Fig.3 shows temple components with similarity to human form.

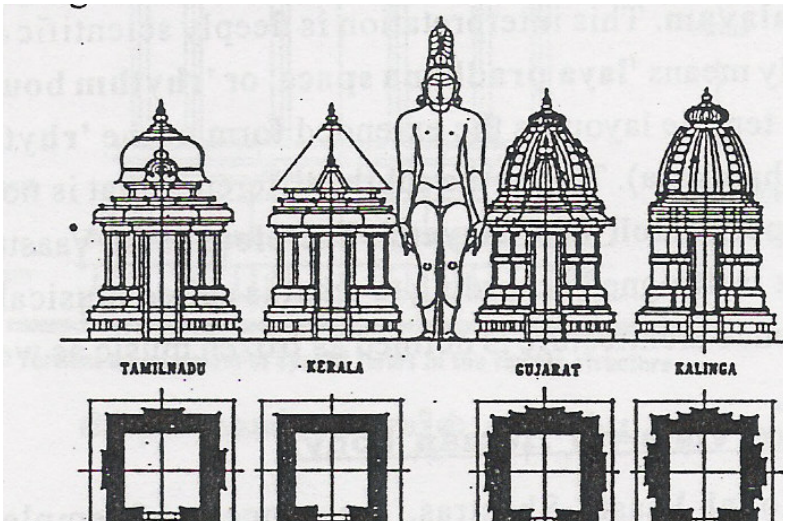

Fig.2: Human form and Different Temple forms (ref.1)

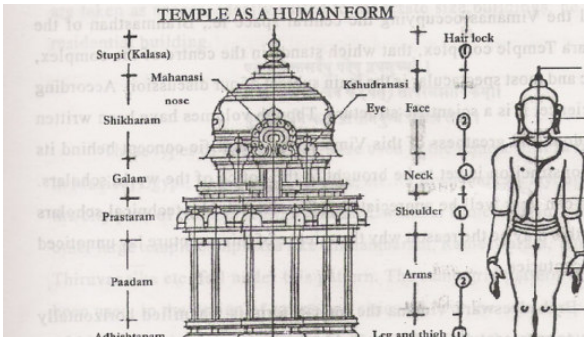

Fig.3: Temple Human Component Similitude (ref.1)

The human parts providing similitude to reflect the spiritualistic approach seen earlier. For example the hair is represented by stupi, the face by shikaram, neck by galam, hands by paadam and feet by upapeetam. Any calculations done towards the size, location and shape have the basis of 'Aayadi Gananam' or purified measures. All these led to a vertical arrangement similar to human form with one unit assigned to feet, legs and thighs, shoulder, neck and hair and two units for arms and face giving a total of nine units which form the basis of form.

Further it deals with space, time, spatial forms and their interplay with the five entities – pancha boothas – land, water, fire, wind and cosmic space. Fig.4 gives an idea of this integral approach of traditional Indian construction which tries to synergise the environment. More details can be found in (2) and many references.

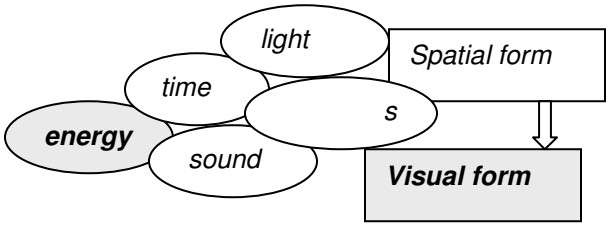

Fig.4: Synergy in Indian Tradition

Structural features and responses

It is preferable to discuss the structural aspects in two separate sub-headings to bring out the diversity and similarity wherever it exists between the two types of construction.

Modern Construction

Present day construction uses materials and technology, which are amenable to modeling and analysis. Even though a complete understanding of the behaviour of concrete is not yet possible, its models have served well for analysis and design using one, two and three-dimensional responses. Typically the stress-strain curve for concrete and steel is shown in Fig.5 for both tension and compression under uni-axial load conditions. Similarly failure models for two and three dimensions have been developed as shown in Fig.6. In Fig.5 the stress-strain curve for tension and compression is similar for steel without buckling effects. Whereas for concrete huge difference is there due its brittle nature. Similarly if one looks at failure under biaxial load conditions as shown in Fig.6 (T-C means tension along X-axis and compression along Y axis) there is symmetry for steel whereas it is not symmetric due to brittle nature of concrete. Here the limits of curves can be prescribed by stress or strain or yield stage or failure stage. The current interest is to overcome the wide disparity between steel and concrete by adding admixtures, fibres and other synthetic materials to make it a composite so that tensile behaviour is better.

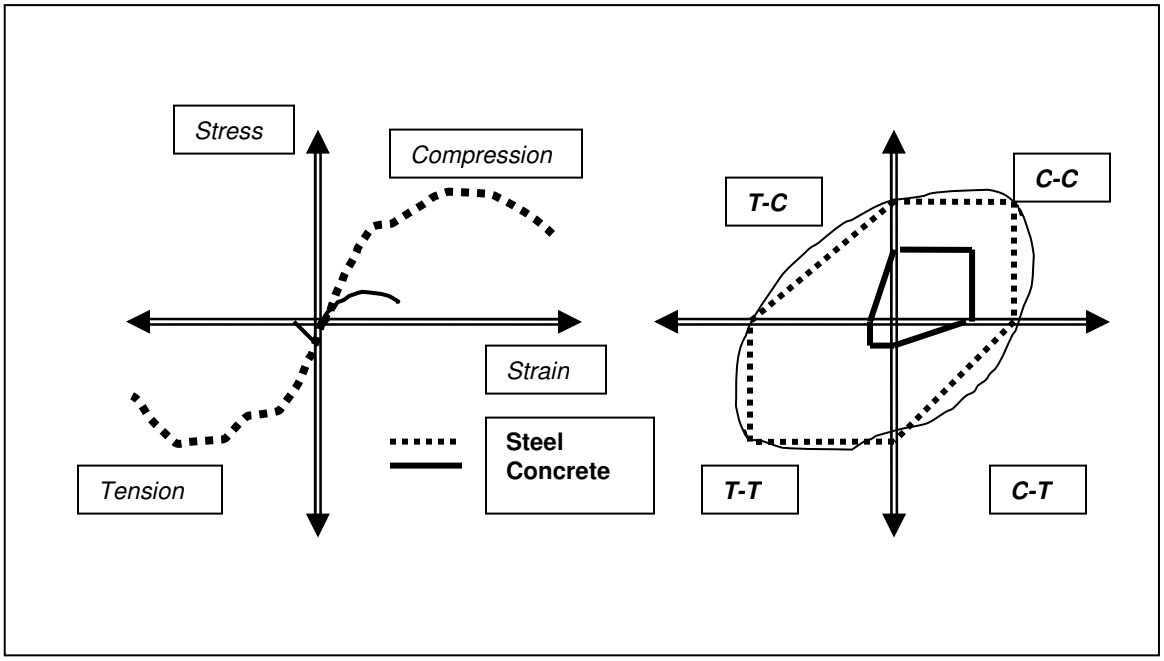

Fig.5: Uniaxial Stress-strain

Fig.6: Failure Curves (T-tension; C-comprn.)

Further the size of the material does play a role in bringing fracture much earlier in concrete making it more flexible if cracks due to fracture are wide spread. Thus the focus is on materials and response under loads to get an idea of safety.

Traditional construction

The first thing which strikes one in traditional construction is its massive nature and a typical simple example of a structure – there are many in the sides of many roads in India- called 'load-bearer' is shown in Fig.7. Here two stone pillars support another stone beam all of which are of similar sizes and have weights in such a way two or maximum three men can lift and place in position. As it is supposed to act as a relief for humans carrying weights, its sizes are reflective of little bending and more shear. Whereas when large column free areas are needed a different system as shown in Fig.8 was adopted.

Fig.7: Load Bearer Structure

Fig.8: Community Hall

Materials used are always stones – granite in most cases – and bricks in later years like the Gangai Konda Sozhapuram, in south India. Rocks are predominantly compression materials and thus sizes of construction are multiples of a rock prism, either a cube or hexahedran or a long

rectangular prism as in Fig.7. The basic labour for construction being humans, sizes reflect the capability of one, two or four individuals' capacity to lift.

Structural responses

Present day construction relies on models like finite element method – FEM – and computers to analyse resulting linear/nonlinear and time dependent equations. Whereas traditional construction looked at the functionality of the system and in that process provided in-built strengths some of which are highlighted in the next section.

Tradition construction nuances

As mentioned earlier any system built in traditional construction should look at the human side. Starting from foundations to different components the approach was one of stability and energy absorption capability. From stability point of view, the form with a wider base and tapering towards top was the standard one except in variations in ratios of base width length and height. For example the basis for the statue – Fig.9 -in Kanyakumari (ref.2) is the number of couplets written in 133 chapters, which span virtue, love and wealth with 38 for basis virtue and remaining 95 (21/2 times 38) for the other two. The construction reflects this. Here the human side of the great poet is taken and merged with his contribution/achievements in a form reflecting this as shown. Similarly procedure for laying foundations consisted of layers of compacted and with organic filling in between. The anticipation was that this would isolate ground movements so that seismic effects re not carried up. This may be the reason why most of the constructions have not shown any cracks even.

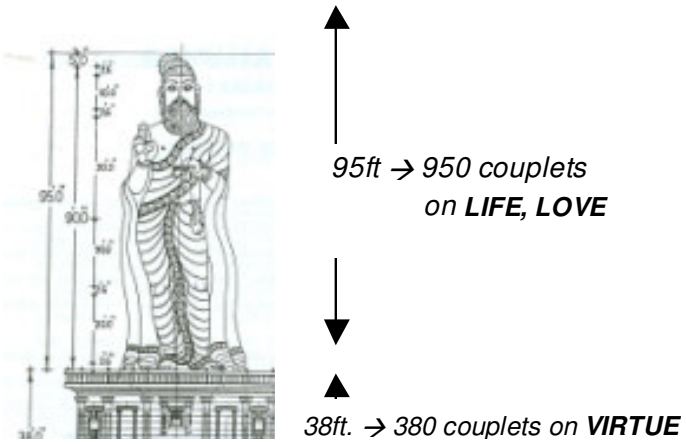

Fig.9: Valluvar Statue in Kanyakumari

The next aspect is in joints and the mortar based on lime and other organic materials had provided a flexible bond between stones to take care of minor movements. Another innovation is in supporting mechanism, which always had been simple supports or rotational ones on spheres as shown in Fig.10. Here the pillars supporting the superstructure have a ball-and-socket type of connection, which releases the moments. This will be a major advantage against unanticipated loads, as the column does not bend much. Fig.11 shows a typical corridor built in this fashion.

Fig.10: Column Supports

Fig.11: Corridor of Columns

Conclusions

Role of Indian traditional construction in the present day construction activity can be a major synergising force in bringing the best- of- both- world making a unique and distinctive contribution without losing the basic Indian traits. After comparing the tradition with modern construction, highlights of Indian models are presented briefly to bring forth the point that there is a lot to look inward!!

References

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