The Study of measurement of over-engineering in construction project

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Abstract - *Over-engineering is the designing of an element to be more robust or complicated than is necessary for its application, either to ensure sufficient factor of safety, sufficient functionality, or because of design errors. Over-engineering can be desirable when safety or performance on a particular criterion is critical, or when extremely broad functionality is required, but it is generally criticized from the point of view of value engineering as wasteful. Over-engineering generally occurs in high-end element or specialized market criteria, and takes various forms. In one form, elements are overbuilt, and have performance far in excess of needs and hence are more expensive, bulkier, and heavier than necessary. For example building material having excess strength and lifespan, unnecessary over dimensioned building units (bedroom, halls, passages etc.), provision of over architectural aspect in building etc. Alternatively, they may be overcomplicated – the design may be far more complicated than is necessary for its use. Over-complexity reduces usability of the element by the end user, and can decrease productivity of the design team due to the need to build and maintain all the features.*

The proposed paper consists of study of various construction elements with over-engineering approach. The elements will be studied w.r.t. different aspect of construction of building from planning, construction to completion stage.

Key Words: Over engineering, building planning optimization, cost effective, value engineering

1.INTRODUCTION

Increasing awareness in construction technology and methodology indicate that issues of sustainability are serious concerns throughout the world. In concrete buildings, conventional on-site construction methods have long been criticized for long construction time, low productivity, poor safety records, and large quantities of waste. The alternative, more innovative approach towards construction practices can offer significant advantages, such as lower project cost, improved quality, less construction site wastage, reduction of energy and water consumption etc. Cost is undoubtedly the most important concern in any business endeavor, not least in the construction industry. Poor cost performance in construction projects has become a major concern for both contractors and clients. In order to control costs, it is important to exercise foresight of the various project-related elements and address the magnitude of their effects. It is agreed that realizing and understanding cost-elements will enrich the cost estimator's competence, hence, adequately delivering a more sustainable and reliable cost modeling and estimating technique. A clearer understanding of the cost elements is vital to achieve the desired level of accuracy of anticipated labor costs, material costs etc. in total cost estimation. The estimator is able to examine these factors and subsequently estimate, plan for, and mitigate the adverse effects of these factors on the project cost.

Over-engineering is the designing of an element to be more robust or complicated than is necessary for its application, either to ensure sufficient factor of safety, sufficient functionality, or because of design errors. Over-engineering can be desirable when safety or performance on a particular criterion is critical, or when extremely broad functionality is required, but it is generally criticized from the point of view of value engineering as wasteful. Over-engineering generally occurs in high-end element or specialized market criteria, and takes various forms. In one form, elements are overbuilt, and have performance far in excess of needs and hence are more expensive, bulkier, and heavier than necessary. For example building material having excess strength and lifespan, unnecessary over dimensioned building units (bedroom, halls, passages etc.), provision of over architectural aspect in building etc.Alternatively, they may be overcomplicated – the design may be far more complicated than is necessary for its use. Over-complexity reduces usability of the element by the end user, and can decrease productivity of the design team due to the need to build and maintain all the features.

Our work consists of study of various construction elements with over-engineering approach. The elements will be studied w.r.t. different aspect of construction of building from planning, construction to completion stage.

2.Objective of Over-Engineering (OE)

In defining objectives of OE in construction sector in identifying cost-saving alternatives, using resources more effectively, decreasing project design, operation and maintenance costs, improving safety programs for major governmental installations. It also assists in reducing paperwork and simplifying procedures and improving project schedule. Furthermore, it has impact on streamlining an agencies organizational structure and cutting down on waste.

OE techniques can be used to achieve saving in money, reducing time and improving quality. In addition, it can be used to improve maintainability and performance. Other achievements of OE are improve in human factors, attitude, creativity and team work as well as improving decision making. OE as to produce results creatively and economically by identifying unnecessary expenditure, challenging assumptions, generating alternative ideas, promoting innovation and optimizing resources, time, money, energy and consideration of whole of life cycle costs. OE aims also to simplify methods and procedures, eliminating redundant features, updating standards, criteria and objectives and improve team performance and other synergies. Other benefits that showcase the evolving nature of Value Management as something more than sophisticated cost reduction tool like improving communication, teamwork and cooperation as well as increasing awareness and ownership by stakeholders. It forms aid to the briefing and approvals process and increasing quality. Enhancing risk management measures, improving sustainability and promoting innovative service delivery processes are also achievements of OE

3.Methodology

In this work following methodology has been decided to measure and manage the over engineering in the construction projects.

1) Collection of information through literature review and or preliminary study on site.
2) Collection of data through questionnaires' devised in the same regards.
3) Finding over engineering in different projects by comparing data collected.
4) Develop a model to assess the over engineering (OE) in a construction project.

4.Overengineering study

Considering all facts and factors the OE study can be restricted with only RCC frame members and its influence on construction of residential building. Thus summarizing all the OE components/ elements as below

4.1Over-Engineering components/ elements

- Area accompanied by single column
- Column Sizes and steel provided
- Beam sizes and steel provided
- Slab sizes/thickness and steel provided
- Column length per floor
- Beam length per floor

Table -1: OE criteria for effectiveness of column utilization

Sr. No.	Total Area (SQM)	No. of Columns	Area per Column	Area per Column	Actual Load (Max) (KN)	Efficiency of column (Actual Load/ Capacity)	Total length of column	Total length of column per floor area (%)
1	1338.00	57	23.47	23.47	1093.2	0.3	855.000	63.90
2	2838.10	56	50.68	50.68	1662.2	0.4	672.000	23.68
3	1112.25	53	20.99	20.99	1019.5	0.3	795.000	71.48
4	1248.55	84	14.86	14.86	699.4	0.2	1344.000	107.64
5	1428.12	72	19.84	19.84	958.0	0.3	892.800	62.52
6	1159.96	50	23.20	23.20	1144.4	0.3	750.000	64.66
7	1589.04	84	18.92	18.92	788.3	0.2	1260.000	79.29
8	411.55	21	19.60	19.60	737.0	0.3	195.300	47.45
9	2003.52	62	32.31	32.31	1111.5	0.4	744.000	37.13
10	528.93	26	20.34	20.34	820.0	0.3	234.000	44.24

The Table 1 indicates the OE exists in placing of columns or in provision of number of column for given area. It also shows the efficiency of column is not utilized properly. In each case of building the efficiency is nearly about 30% to 40%. This indicates the OE exists in provision of sizes of column for given area. The percentage length of column is varying. As the value increase the cost of projects affects. It is to be noted that the column length per unit floor area does not show much variation w.r.t height of floor provided.

This may be happening due to uncertainties in construction project like quality control, future expansion, and lack of critical awareness in construction management etc. This may be happening due to uncertainties in construction project like quality control, future expansion, and lack of critical awareness in construction management etc.

Table -2: OE criteria for Beam- slab utilization

Sr. No.	Total Area (SQM)	Total length of beams (meters)	Weight of beam per floor area	Total Volume of slab	Total % of steel utilized in slab	Total beam length	Beam length per unit floor area
1	1338.00	2274.00	5.3	200.70	0.60	2274.00	0.34
2	2838.10	1799.20	1.8	354.76	0.50	1799.20	0.16
3	1112.25	2035.00	6.1	166.84	0.80	2035.00	0.37
4	1248.55	1936.00	4.8	174.80	0.90	1936.00	0.31
5	1428.12	2112.80	4.6	214.22	0.70	2112.80	0.37
6	1159.96	2236.00	7.0	173.99	0.60	2236.00	0.39
7	1589.04	1920.00	3.6	238.36	1.00	1920.00	0.24
8	411.55	249.60	1.7	61.73	1.09	249.60	0.20
9	2003.52	1288.00	0.7	300.53	0.50	1288.00	0.16
10	528.93	396.00	1.6	63.47	0.90	396.00	0.25

The table 2 shows the weight of beam per area is varying and it does not show any consistency with the total area of building. In each case of building the weight per floor area is not constant. The value mentioned (weight of beam per floor area) directly affects the quantity of material as well as cost of building. This indicates the OE exists in provision of beam sizes, location ultimately planning of building. It also shows although slab thickness is not varying too much. But the percentage of steel does not show any consistency with the total area of building. In each case of building the steel per unit floor area is not constant. The steel per floor area affects the quantity of steel and hence cost of building. This indicates the OE exists in provision of slab sizes and steel reinforcement. It shows the Beam length per unit floor area is not constant. As the value increase the material required per unit area also increases. It is to be noted that the beam length per unit floor area does not show much variation w.r.t number of columns provided. The main governing factor for this OE is optimum arrangement of beam grid for given plan of building.

The reason behind this variation is planning of building. The architectural approach towards planning may not give a similar pattern all the time. As per planning of building, beam arrangement will change w.r.t size, orientation, location etc. And from survey, observation and table 2 it is clear that square or rectangular pattern (planning) gives the economical results. The reason behind this variation may be planning of building to some extent. As per planning of building, beam arrangement will change and hence slab pattern changes. The provision of maximum two way slabs, cantilevers and too much short span slab (one way) results uneconomical construction.

5.Discussion on Deciding Optimum Planning Solution

Columns are main member of RCC frame building. As seen in previous chapter the provision of number of columns is not consistency with area of building. It utilized efficiency is very much lesser. Looking at efficiency values one can go with 100% efficient values. But the other factors like future requirement of expansion, quality control, other stuffs, the 60 % efficiency is ideal. Out of remaining 40%, probability of future requirement may be considered as 30% and for quality control & other stuffs around 10%.

The length of column per floor increases with the number of columns and floor height. In most of cases the height of columns is fixed for whole building but the numbers are varying w.r.t. plan area. If the area per column criteria is used for analysis then the this value tends to optimize for all building plans.

Beam length and size varies as columns arrangement and numbers varies. If beam length is more cross section and steel increases affecting economy. If beam length is too short then grid effect adds conjunction of unutilized beam sections. Hence proper size and optimum orientation and planning will give best feasible solution

All it can be conclude that depending upon the size of building and size of column an optimum number of columns can be determined.

Table -3: Size of columns and optimum area

Size of column	Optimum area (Approx. near to)
300 x 900	65 sq.m.
300 x 750	45 sq.m.
300 x 600	40 sq.m.
230 x 450	20 sq.m.
230 x 380	15 sq.m.

For OE criteria Column length per floor automatically optimized when the number of column are optimized.

For OE criteria, Beam length per floor is crucial point. It will be minimum at the situation when suitable numbers of column are provided. Since the column grid points are fixed, beam network will be optimum.

5.1Optimum Columns

Optimum column is the column which has the optimum cross sectional area and optimum steel. This column always gives an economic solution for building. The column size and steel may vary according to situation like number of stories, area for single column provided etc. but it will be a best choice to reduce the cost for OE.

To achieve material efficiency in terms of RCC frames member columns, the trial and error approach can be considered. For this various sizes of columns subjected to effective column loads can be considered. The quantity required for this is calculated. The comparison of each case studied will give the best solution for optimum columns.

5.2 Optimum Beams

Optimum beam is the beam which has the optimum cross sectional area and optimum steel. This beam always gives an economic solution for building slab-beam grid. The beam size and steel may vary according to situation like span, beam grid prepared etc. but it will be a best choice to reduce the cost for OE.

To achieve material efficiency in terms of RCC frames member beams, the trial and error approach can be considered. For this various sizes of beams subjected to different loads, spans etc. can be considered. The quantity required for this is calculated. The comparison of each case studied will give the best solution for optimum beams.

5.3 Optimum Slabs

Optimum slab is the slab which has the optimum thickness and optimum steel. This slab always gives an economic solution for building slab-beam grid and orientation. The slab size and steel may vary according to situation like span, orientation considered etc. but it will be a best choice to reduce the cost for OE.

To achieve material efficiency in terms of RCC frames member slabs, the trial and error approach can be considered. For this various sizes of slabs subjected to different loads, spans etc. can be considered. The quantity required for this is calculated. The comparison of each case studied will give the best solution for optimum slabs.

6.CONCLUSION

The existence of over engineering lies in construction of building cannot be neglected. The various computational efforts done shows that the RCC frame members are may be the major part in over-engineering. Thus by taking care of RCC frame members one can avoid Over-engineering in Construction Industry.

Various computational approaches towards the RCC frame member's evaluation in terms of quantities and cost effectiveness shows the existence of over engineering.

The measurement of OE is possible with measuring following quantities in building

- Area accompanied by single column
- Efficiency of column i.e. ratio of actual load and capacity of column
- Total length of columns for structure
- Weight of beam per area of floor
- Steel per unit floor area of slab
- Beam length per unit floor area

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