



Development of software for minimization of wastes in rebar in rcc structures by using linear programming

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Abstract—A Civil Engineering constructor often encounters problems of more wastages of steel reinforcement because of large number of lengths of reinforcing steel used in construction but there are only few standard lengths of reinforcing steels produced by steel industry in India. In construction, therefore, it is necessary to cut the steel from the standard lengths, causing a large amount of wastes of reinforcing steel remain at the job site. The amount of reinforcing steel needs in India in this current year (2015-2016) is approximately 37.6 million tons. According to reported literature there is a waste of 5 % from using reinforcing steel, it will be 1.88 million tonnes of steel waste per year. The price of reinforcing steel is Rs 44,500/ton, then this will lead to a loss to the whole construction industry in India up to Rs 8366 Crs per year. According to Industrial review in this regard, steel rebar waste savings due to optimization is to the tune of 3 %, thus Money savings by Construction industry in India could be Rs 5020 Crs per annum. The study is divided into two steps. The first step is collecting bar bending lists and percentage of wastes caused by cutting steels. The second step is finding the method to minimize waste due to the cutting. The research implements the combination theory in order to generate all possible cutting patterns of reinforcing steels and mathematical programming theory to solve for the patterns that yield minimum waste. Through this research and development project indigenous software is proposed to be developed in order to generate cutting patterns, formulate mathematical model, and solve the model. On successful testing of the software, it will be made available to the Construction Industry in India through series of Workshops and seminars, so that waste-full expenses in large scale can be saved in India, every year and in future also.

Introduction

In building construction industry, the structure that is most often built is based on reinforced concrete because it cost less than other types of structures. The major cost of the structure consists of concrete, reinforcing steel, and formwork. Concrete, reinforcing steel are permanent materials that exist along with the life of the structure while formwork is considered to be a temporary work will be removed after the structure can support itself. Internationally it has found that the normal percentage of waste of reinforcing steel in general reinforced concrete building is approximately 8.9. However a construction

project that has a very good controlling system, the percentage of waste of reinforcing steel can be reduced to 6. The estimated Steel Rebar demand in 2015-16 is 37.6 Million Tonnes, and is projected to reach around 42 million at a CAGR of 8.28 percent in 2020-21. The amount of reinforcing steel needs in India in this current year is approximately 37.6 million tons. If there is a waste of 5 % from using reinforcing steel, it will be 1.88 million tonnes of steel waste per year. If the unit cost of reinforcing steel is Rs 44,500/ton, then this will cost loss to the whole industry in India, Rs 8366 Crores per year. According to international review in this regard, steel rebar waste savings due to optimization is to the tune of 3 %, thus



Money savings by Construction industry in India could be Rs5020 Crores per annum.

Reinforced concrete is a mixture of concrete and steel reinforcement. Concrete is weak in tension and cracks easily when it shrinks and creeps under sustained loading. It is a brittle material. When concrete fails, it breaks suddenly. Steel on the other hand is 100 times stronger in tension than concrete; is 6 times stiffer; and will stretch 17 times more than concrete before breaks. Steel reinforcement provides reinforced concrete the tensile strength, stiffness and ductility need to make it an efficient, durable, versatile, and safe building material.

For reinforced concrete to work as the Designer intend the Inspector and Resident Engineer must ensure that reinforcing steel placed in the structure is

- The proper grade and type of steel
- the proper size, shape and length
- placed in its specified location and spaced correctly
- Tied and spliced together correctly
- clean and will get an adequate cover of concrete in all directions
- Placed in the correct quantities.

Objective

The main aim is to reduce the rebar cutting wastages by 3 - 5 % during construction phase through Optimal Computerized Rebar Cutting Planning, will help to reduce (Steel Re Bar) in consumption Reinforced Concrete Buildings and Structures, which will save Rs 5020 Crs per annum in India as a whole

and help to increase productivity of the Nation.

Scope

To develop an Indigenous commercial software to save cost of Rebar wastages in Construction Industry, in India.

Benefits

- Reducing the cost of reinforcing steel in construction
- Reduction in Energy consumption
- Reduction in specific raw material consumption
- Improve the productivity
- Reduction in emission and control of pollution
- Increase in waste utilization

Optimization Software for Reinforced Steel Bar End Cutting

The increasing steel price makes a tool with a high quality algorithm to reduce steel waste more important. The optimization of reinforced steel bar estimates is a classical cut optimization problem with the one exception, because reinforced bars are cut in different lengths with standard measuring units the algorithm should be able to select the best steel length with lesser scrap waste therefore minimizing the cost and steel wastage. Hence the objective of this study is to find a method for reducing waste of reinforcing steel from cutting. Christo Ananth et al. [7] proposed a system, this fully automatic vehicle is equipped by micro controller, motor driving mechanism and battery. The power stored in the battery is used to drive the DC motor that causes the movement to AGV. The speed



of rotation of DC motor i.e., velocity of AGV is controlled by the microprocessor controller. This is an era of automation where it is broadly defined as replacement of manual effort by mechanical power in all degrees of automation. The operation remains an essential part of the system although with changing demands on physical input as the degree of mechanization is increased.

Materials and Methods

The data that are needed for the analysis are bar bending list that show type, size, length and number of each reinforced bar used in construction. This data are used to generate possible cutting patterns. The data will be collected from construction projects that have preparation of bar bending list. For construction project that have no bar bending list, the data were prepared from the detailed drawings of those projects.

Data gathering techniques

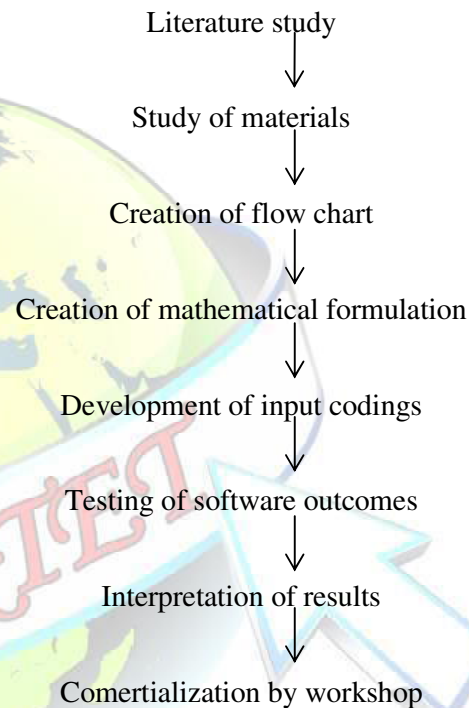
It is proposed to conduct surveys using informal interviews and documentary analysis to gain background in the analysis of steel cutting and estimation for foundation, beam and columns and follow through the mathematical concepts with technological application necessary to finding solution to the present problem.

Meanwhile the **source of data** for the three objectives requires intensive idea on steel estimation so this will be learned from the document analysis of the estimate form in the Simplified Construction Estimates.

The **conceptual framework** follows the objectives of the study which is focused on the evaluation of bin packing and cutting stock algorithm, identification of the weakness of the bin packing cutting stock algorithm and design of a modified bin packing and cutting stock algorithm to determining the efficiency of the

modification done. The whole process is aimed to create an impact to developing an efficient and effective modified algorithm can be used to optimize reinforced steel bar estimation that will be applied later in a computer application to select the best steel length with lesser scrap to be applied to foundation, beam and column of any structural plans for housing and even for building constructions.

Research methodology



Cutting Pattern of Reinforcing Steels

To generate all possible cutting patterns, the combination theory will implemented. The total number of all possible cutting pattern can be calculated. In construction, the number of lengths of reinforcing steel is quite varies from 1 to 100. The number of possible cutting patterns depends on the number of required lengths (N) and the number of reinforcing steel in the one group (r). This number is too large and difficult to change to mathematical equations and solve for the solution, hence Computers with appropriate software are



proposed to be used to reduce the cutting waste reduction.

Creating Mathematical Model

This step creates mathematical equations in order to change qualitative problem to quantitative problem that can be solved. The problem can be analyzed in the class of cutting stock problem.

Finding The Solution

In the case that the number of lengths of reinforcing steels is not high and manual calculation can be done in order to generate cutting patterns, variables, equations, and solve the equations. However the collected data shows the number of lengths of reinforcing steels is high and the manual calculation is not suitable. As a result the computer program is need to be developed.

Main Procedures of Developing Software Program

Develop a subprogram for input data

A subprogram for inputting data is needed in order to keep the data as a file can be used later. The data include the length of reinforcing steels and the amount of reinforcing steel for each length.

Develop subprogram for calculation process The calculation process can be divided into 3 steps.

Generating all possible cutting pattern

This subprogram generates all possible cutting patterns using data from the previous step. Each pattern will be checked with the assumptions if it passes the assumptions, and then the pattern will be used as a variable will be saved as a string variable in a data file.

Developing mathematical model

This subprogram uses the string variables from the data files in the previous steps to formulate the mathematical model in a matrix form ($m \times n$). This step uses assumption, in order to limit the number of variables in order that they can be solved. The mathematical model includes variables (X_j), coefficients (a_{ij}), waste (C_j), and amount of steel for each length (b_i). The mathematical model will be saved in a data file.

Solving the model

The model from the above step can be solved using any mathematical programming software, for instance, Microsoft Excel Solver. However to eliminate the interfacing between different software programs, this research uses a subprogram that has been developed by the authors in order to solve the model. The subprogram is verified by comparing the solution from the subprogram with the solution from using excel software (Excel Solver). The solution from the subprogram will be saved in a data file for the next step.

Develop a subprogram for output

This subprogram generates output using the solution in the previous step. The output shows the number of cutting patterns needed, standard length(s) used, and the fractions from the cutting patterns.

conclusion

The study shows that the construction projects that have bar bending list during construction has less waste than the projects that have no bar bending list during construction. However, arrangement of cutting patterns can



directly reduce waste from cutting steels. The analysis implements combination theory in order to find all possible cutting patterns. Then, the cutting patterns are changed to the mathematical model. The model is solved by the subprogram developed by the author. The comparison between wastes of reinforcing steels from collected data and from the analysis shows that the wastes from the analysis is much less than those of collected data. Therefore, this method shown in this study should be implemented in real construction projects. The method may be applied to other cutting problem, for example, cutting timbers or cutting structural steels that have limited numbers of standard lengths.

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