ACCIDENTCIAL PROGRESSIVE COLLAPSE ANALYSIS TALL BUILDING AND ITS COST MANAGEMENT

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Abstract - *The main objective of this study is to investigate whether concentric, eccentric bracings and MRF steel structures that have been designed based on seismic codes, are able to resist progressive collapse with damaged columns in different locations under seismic loading. For this purpose, 3-D push-over analysis of structures is carried out. The progressive collapse potential has been assessed in connection with 20-story tall buildings with 4 bay by applying the alternate load path method recommended in UFC and GSA 2013 guidelines. Member removal in this manner is intended to represent a situation where an extreme event, such as vehicle impact or past earthquake shock or construction error, may cause a critical column, as a result of local or global buckling, to lose a part or whole of its load bearing capacity. In the case of braces and middle column removal, the structure is minimum stiffness when compared with other different cases. The influence of story number, redundancy and location of critical eliminated elements has been discussed. And finally cost management in done.*

Key Words: Management, Building, Money, Cost.

1. INTRODUCTION

The term progressive collapse is typically used to refer the spread of an initial local failure within the structure. The research of progressive collapse in structures generally focuses on gravity and blast loading. Nevertheless, earthquake load may also cause progressive collapse because of partial or complete failure of critical element as a result of vehicle impact or past earthquake shock, or design and construction error.

The local failure is triggered by loss of one or more load carrying members and lead to partial or total collapse of the structure. Following the initial event , the structure seek alternative load path to transfer the load carried by the damaged portions to the adjacent undamaged members. Therefore, the main feature of progressive collapse is that the final state is disproportionately greater than the local damaged that initiated the collapse.

The progressive collapse of structures is commenced when the primary component (s), usually columns, is eliminated. When a column is suddenly removed as a result of a vehicle collision, explosion, earthquake and other natural or artificial hazards, gravity loads (Dead Load and Live Load) gets transmitted to adjoining columns in the structure. If these primary elements are not appropriately designed to bear and redistribute the overloading, that portion of the structure or the whole of the structure may collapse. The columns of a building persist to fail until the extra loading on the column becomes steady. Consequently, a significant portion of the building may fall down because of the larger and superior damage to the building than the preliminary impact.

1.1 SIGNIFICANCE OF PROGRESSIVE COLLAPSE

Although progressive collapse is generally a rare accident in developed countries, but its effect on buildings is very dangerous. Without significant consideration of adequate continuity, ductility and redundancy, the progressive collapse cannot be prevented. The progress of consecutive damage during the progressive collapse, which occurred in Alfred P Murrah building in Oklahoma City, in 1995, resulted in 168 fatalities.

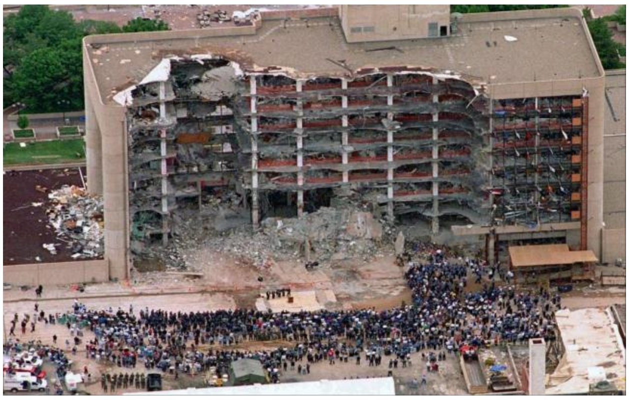

Fig 1.1 Alfred P Murrah building

2. SOFTWARE USED

- SAP2000 Version 18 is a stand-alone finite-element-based structural program for the analysis and design of civil structures.
- SAP2000 is a software application used for modeling, analysis and visualizing the finite element analysis result.
- It offers an intuitive, yet powerful user interface with many tools to aid in the quick and accurate construction of models, along with sophisticated analytical techniques needed to do the most complex projects.

2.1 SAP

The finite element analysis program RFEM is a powerful software for quick and easy modeling, structural analysis and design of 2D and 3D models consisting of member, plate, wall, folded plate, shell, solid, and contact elements.

Due to the modular software concept, you can connect the main program RFEM with the corresponding add-on modules in order to meet your individual requirements Buildings made of reinforced concrete, steel and timber can be subjected to static and dynamic calculations and designs in the structural analysis programs RFEM and RSTAB.

The corresponding add-on modules can perform the ultimate and serviceability limit state design as well as fire resistance design and stability analysis

2.1.1 RFEM - FEM Structural Analysis Software

The structural analysis program RFEM is the basis of a modular software system. The main program RFEM is used to define structures, materials, and loads for planar and spatial structural systems consisting of plates, walls, shells and members. The program also allows you to create combined structures as well as model solid and contact elements.

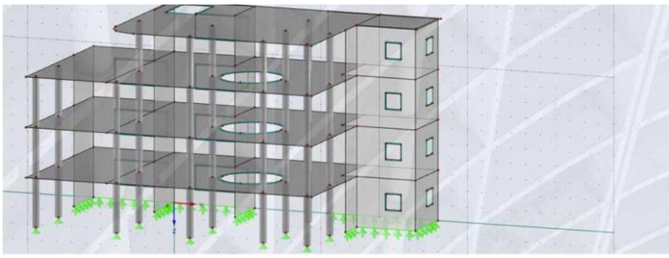

Fig 2.1.1. RFEM - FEM Structural Analysis Software

2.1.2 RSTAB - Structural Frame & Truss Analysis Software

RSTAB is the basis of a modular software system and provides intuitive modelling of simple and complex structures due to its ingenious input technique. The efficient RSTAB solver allows for linear and nonlinear calculations of internal forces, deformations, and support reactions.

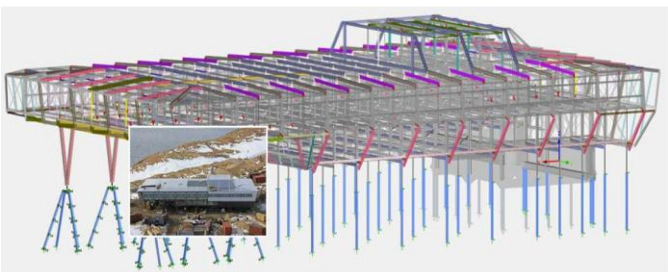

Fig 2.1.2. RSTAB - Structural Frame & Truss Analysis Software

2.1.3 RWIND Simulation - Wind Simulation

RWIND Simulation is a stand-alone program for numerical simulations of wind flow (digital wind tunnel) around buildings or any other objects and generating wind loads, i.e. forces acting on these objects.

This program was developed in cooperation with PC-Progress and CFD Support and can be used as a stand-alone application or as a complement to RFEM / RSTAB programs for static and dynamic analysis.

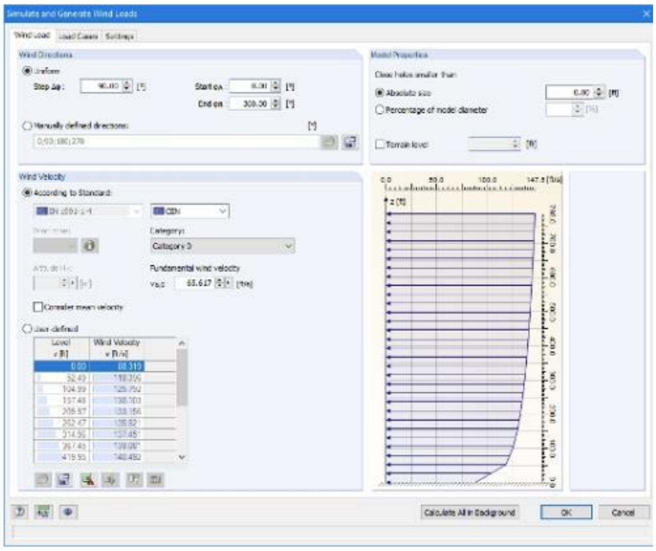

Fig2.1.3. RWIND Simulation - Wind Simulation

2.1.4.COMPUTATIONAL OF MODELLING CRITERIA

Step 1 : Create The Model As Per Required Dimensions.

Step 2: Define Material Property And Frame Section For The Created Model.

Step 3: Add Frame Objects

Step 4: Add Restraints

Step 5: Draw Frame Objects

Step 6: Define load patterns

Step 7: Assign Load Patterns to the Structure in One Way Distribution And Two Distribution.

Step 8: Assign Rigid Diaphragm Constraint for Individual Storey

Step 9: Define Response Spectrum Function

Step 10: Define Response Spectrum Load Case

Step 11: Define Mass Sources

Step 12: Save Model and Run the Analysis

Step 13: Apply Base Shear Correction for the Structure21

Step 14: Define Load Combinations

Step 15: Review the Results

Step 16: Steel Frame Design

3. MODELLING

3.1 GENERAL

The finite element analytical software SAP2000 is a computational tool for modeling structures. It mainly helps to find ultimate load and behavior of model in failure mode, stress criteria, displacement criteria and other useful values like reaction under load and rotation etc.

3.2 MODELING STEPS

- Modeling has been done in SAP2000.
- The beam and column were modeled as frame element.
- The foundation is of fixed condition.
- The in plane rigidity of the floor slab has been simulated using rigid diaphragm constraint. Both the floor and roof system were modeled as rigid diaphragms and were assumed to be non-composite with the steel framing.

Acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

3.3 TYPICAL FLOOR PLAN AND ELEVATION OF THE DIFFERENT BUILDING.

3.3.1 MODEL FOR K-BRACED BUILDING

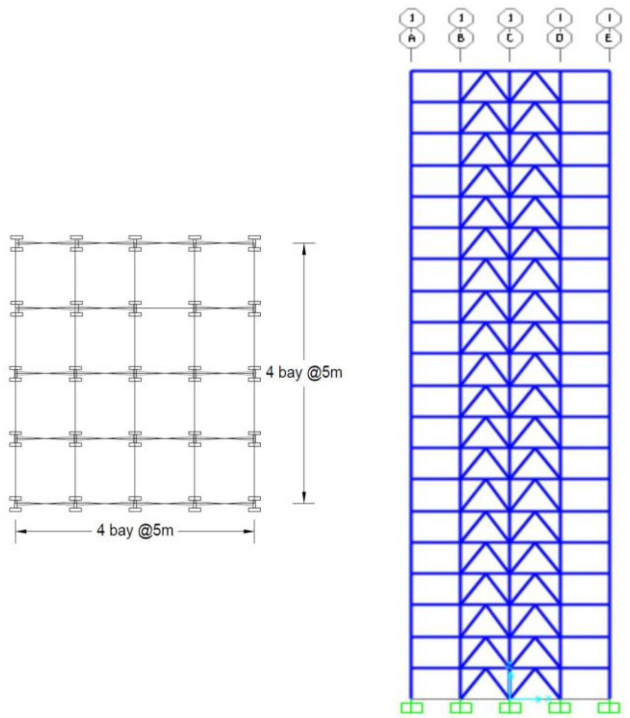

Fig. 3.3.1 plan and elevation of the k braced building

4. PRE-CONTRACT COST MANAGEMENT

- ❖ When developing an estimate the following factors need to be considered:
- ❖ Land acquisition including legal fees;
- ❖ Client's own organization costs allocated to the project (this obviously varies but can be as much as 10% of the overall project budget);
- ❖ Site investigation (frequently underrated and under-budgeted resulting in unnecessary extra costs and time – could be as much as 1% of budget);
- ❖ Enabling works, decontamination;
- ❖ Insurances (many major clients prefer to insure against the risks and take out a project insurance policy covering both themselves and the contractor – may be up to 1% of the budget);
- ❖ Consultants' fees including design (on large transportation and infrastructure projects this can be as much as 15–20% of the budget);
- ❖ Construction costs (typically account for between 70% and 80% of the project sum) (excluding land);
- ❖ Contingency and risks (covers for the unknown and may be between 20% and 25%) or if project of long duration the contingency factor could be double or triple these items;

4.2 Cost estimating on engineering, manufacturing and process industries.

4.2.1 Order of magnitude estimate

This order of magnitude or ballpark is produced for the rapid evaluation of commercial possibilities and economic viability of a project. Since little detail will be normally available the estimate will usually be based on data from a similar previous project updated for time, location, changes in market conditions, current design requirements and relative capacity.
In the absence of data from a near-duplicate project, the estimator will rely on published or historical data from a number of existing projects, usually related to the overall size or capacity of the project or facility concerned, adjusted as necessary. An order of magnitude estimate will typically have an accuracy of – 25% to +50%.

Typical examples of this type of estimating include the following:

1. Cost per megawatt capacity of power stations;
2. Cost per kilometer of highway;
3. Cost per ton of product output for process plants;
4. Cost per car park space (multi-storey car park), pupil (school), beds (hospital) etc.

The key issue to consider when using this approach is comparing like with like: Are the standards the same in the previous projects? Does the price include infrastructure? Are professional fees and financing costs included etc.? Despite these concerns an order of magnitude estimate can be useful, particularly at the conceptual stages of projects when information is very limited and alternatives have to be ranked quickly.

This approach is probably realistic for all complex major projects, including civil engineering and building. It is based on the concept that the degree of accuracy of the estimate is only as good as the level of detail available. In practice, clients often demand certainty of outcome from inception requiring the design team to successfully manage the development of the design within the initial budget.

4.2.2 Appropriation estimate

In the engineering and process industries, the appropriation estimate is sometimes referred to as the Class III estimate as it uses information developed to a level of definition described as Class III. At this stage the designers will have identified the major equipment and determined their required outputs. This will provide an opportunity to enable the estimator to make enquiries of potential suppliers regarding the availability and price of key components. The appropriation estimate will typically have an accuracy of –15% to +25%.

4.2.3 Cost estimating on civil engineering projects

One of the benefits of cost management in the pre-contract stage, especially in multi- contract projects, is that it helps the project team to better establish the appropriate project contract strategy. That is, which work should be placed in Which contract and possibly the form of contract which should be adopted for particular contracts? Cost management can also help identify possible program restraints both in contract preparation and execution.

The preparation of the first estimate would be based on a variety of techniques, for example, historic data or approximate quantities. Major projects often have substantial elements that are unique and for which there is no relevant historic data. In these cases it is necessary to analyze the project in as many individual work sections as can be identified, if possible to prepare indicative quantities and consider the resources necessary to carry out the work. During this indicative stage it is wise to contact potential contractors and manufacturers especially with regard to order-of-cost estimates for specialist sections.

During the process of design development the main duties of the quantity surveyor as part of the cost management team are as follows:

1. to check and report the cost of design solutions as they are established or refined by the engineers;
2. to prepare comparative estimates of various design solutions or alternatives and advise the engineer accordingly;
3. As changes are introduced into the project, to estimate the cost effect of the change and to report;
4. To prepare a pre-tender estimate based on a bill of quantities (BofQ) or priced activities;
5. To prepare a financial appraisal.

4.2.4 Cost bidding on building projects

Cost management is the total process, which ensures that the contract sum is within the client's approved budget or cost limit. It is the process of helping the design team design to a cost rather than the QS costing a design.

The basis of the design cost control using the cost-planning technique is the analysis of existing projects into functional elements in order to provide a means of comparison between projects planned with data from existing projects. A building element is defined as part of a building performing a function regardless of its specification. Elemental analysis allows the comparison of the costs of the same element to be compared between two or more buildings.

5. CONTRACTOR'S ESTIMATING AND TENDERING

Introduction

The estimating process is very important, as it enables construction companies to determine their direct costs, and provides a bottom line cost below which it would not be economical for them to carry out the work.

Overestimated costs result in a higher tender price and rejection by the client. Likewise, an underestimated cost could lead to a situation where a contractor incurs losses. If the contractor is selected then the estimate should also provide the basis for project budgeting and control.

A study by Al-Harbi et al. (1994) identified that the main problems facing estimators in Saudi Arabia while compiling tenders for building works included tough competition, short contract period, incomplete drawings and specification, incomplete project scope definition, unforeseeable changes in material prices, changes in owner's requirements, current workload, errors in judgment, inadequate production time data, lack of historical data for similar jobs and lack of experience of similar projects. These items indicate the challenges faced by estimators no matter where the work is carried out.

However, before any estimates can be submitted the first step for contractors is to get onto the tender lists. This could be done on an ad hoc basis or preferably in accordance with a sort of longer-term strategic marketing plan that is usually of a five-year duration. The five-year plan, which should be based on an analysis of the past and consideration of the future trends within the market, should be re-examined on an annual basis and modified accordingly.

6. Components of the structural frame cost.

It is often assumed that a frame with the minimum tonnage will also have the lowest cost. However, as the figure (left) shows, the raw material cost typically accounts for only 30-40% of the total frame cost, with fabrication costs also accounting for 30-40%. For more complex frame designs, with higher proportions of non-standard sections, complex connections or specialist systems with higher fabrication requirements, the overall rate per tonne is likely to be higher than for a standard frame.

The construction of the steel frame typically accounts for around 10-15% of the total frame cost. It is therefore necessary to consider whether there are features of the proposed building that would significantly affect the erection cost as this will see a corresponding impact on the total cost of the frame. The extent of repetition, piece count, the type of connections to be used and access can all have a significant impact on the cost of constructing the frame.

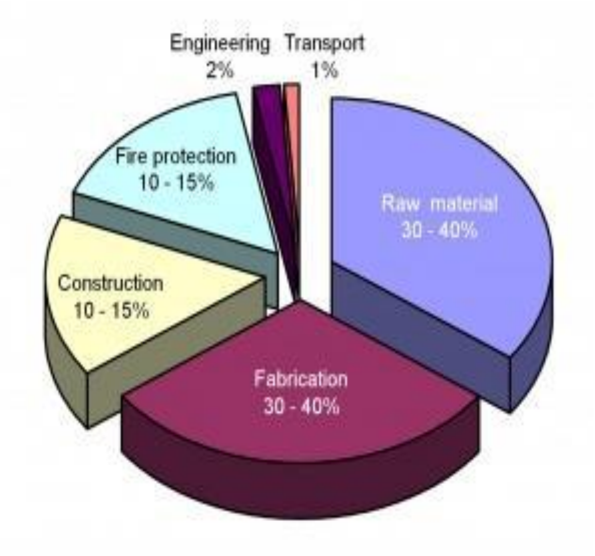

Fig6. Components of the structural frame cost

6.1Cost comparison study

November 2011, the BCSA and Tata Steel commissioned Gardiner & Theobald (G&T), Peter Brett Associates (PBA) and Mace Group to undertake an impartial study of current construction practice for multi-storey office construction to provide cost and programme guidance for Quantity Surveyors and design teams. PBA identified and designed representative framing solutions for two typical office buildings (Building 1 - A business park office, and Building 2 - A city centre office). G&T provided cost information for each frame option and Mace considered buildability, logistics and programme. PBA also carried out a cradle-to-cradle embodied carbon assessment on Building 2. The costs were regularly updated by G&T through to October 2016, and published quarterly in Building magazine as the 'Steel Insight' series.

The series comprises studies into office, education, residential/mixed-use, retail and industrial buildings, and a key feature is a series of building type specific cost comparisons based on actual buildings. The buildings selected were originally part of the Target Zero study conducted by a consortium of organisations including Tata Steel, AECOM, SCI, Cyril Sweet and BCSA in 2010 to provide guidance on the design and construction of sustainable, low and zero carbon buildings in the UK.

7. CONCLUSION

This study concludes the construction of steel bracing designed according to the seismic codes to avoid the accident in the building various design software's are been used in the project for the design of the steel structure.
The cost management in the construction of steel structure.

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