Post-doctoral Proposal

MODELING OF BEAM-TO-COLUMN JOINTS OF STEEL CONCRETE COMPOSITE FRAMES SUBJECTED TO STANDARD AND EXTREME LOAD COMBINATIONS

Dr. Bashir Saleh
Steel-Concrete Composite Frame Designer and Applied Finite Element Analysis
LS-DYNA, ABAQUS, MSC-PATRAN.
TABLE OF CONTENTS

1. Summary .................................................................................................................................................. 2
2. State of the art .......................................................................................................................................... 2
3. Objectives and emerging Post-doctoral project research needs ............................................................... 2
4. Work plan ................................................................................................................................................. 3
7. References .............................................................................................................................................. 3
1. SUMMARY

The present proposal aims to expose the actual interest on developing a Post-doctoral project in the area of the Civil engineering structures, including buildings, can be exposed to natural disasters such as earthquakes, hurricanes, floods, fires, and the risk of man-made disasters such as the impact or an explosion. These buildings are usually designed as ordinary structures to carry only service loads that can occur during their life, but for extreme events, such a design is not sufficient, and therefore may lead to catastrophic event. Recently, events such as the terrorist attack on the World Trade Center have led to structural failure and collapse, leading to loss of life and staggering economic losses [2, 3, 9].

In this research, the focus is on dynamic behavior as we compare experimental results with numerical results in terms of the moment resistance and rotational capacity of the isolated joints when subjected to sagging and hogging bending moments. The flush end-plate with 4 bolts and asymmetric extended end-plate with 8 bolts joints will be conducted and investigated in detail as the previous research which took place in Rzeszow University, where the focus on the static behavior [1, 4], and for the postdoctoral research the focus on dynamic behavior. For this work, I have in mind to use advanced dynamic simulation techniques using ABAQUS and LsDyna, which probably will include the 3D modelling of an interactive prototype of a possible machine. All previous results on the static effect [5], will be comparable to dynamic results of the postdoctoral project, as well as the modeling results, and come up with recommendations that will add to the Eurocodes on the structural design of Civil Construction steel-concrete composite framework, when those construction exposed to unexpected events. The results provides a great deal of safety and the reduction of the previous losses.

2. STATE OF THE ART

After major collapses of some buildings recently, for example the frameworks of the steel and composite buildings in the Northridge and Kobe earthquakes, a lot of research on the reliability and robustness of the steel and composite frames has been carried out. In particular, extensive research related to the resistance and ductility of joints that would be expected less likely to fail during earthquakes and other extreme events has been conducted. Researchers and engineers in the field of Civil Engineering are now moving toward performance-based design of structures to increase durability taking into account the necessary flexibility in the joints. A review of the literature leads to the conclusion that there is broad evidence concerning global and local behavior of frameworks in standard situations of load combinations and rather limited knowledge of the local behavior of joints in frames during such an extreme event as the loss of a column.

3. OBJECTIVES AND EMERGING POST-DOCTORAL PROJECT RESEARCH NEEDS

Important aspects of joint behavior in relation to the progressive collapse phenomenon that require post-doctoral research can be summarized as follows:

- There is a need for more experimental evidence on the behavior of joints between steel columns and composite beams under sagging bending. Laboratory tests might be arranged for isolated joints under bending and next under bending associated by a tensile force of different levels applied to composite beams in a static manner. This would allow for the collection of data on experimental joint properties and moment-rotation curves for several values of tensile forces enabling the evaluation of M-N strength diagrams (where M is the sagging bending moment and N is the axial tensile force) and evolution of the joint properties, like stiffness, strength and rotation capacity with regard to the contribution of membrane deformations. Knowledge on isolated joint stiffness, strength and ductility referred to standard situations and static loading needs to be expanded towards the influence of deformation rate of joints behaving in extreme situations of local damage. If local damage of frameworks is simulated by a column loss scenario, beam-to-column joints in the damaged area are subjected to impact loading and different rate-dependent deformation conditions. It is therefore important to relate the experimental and numerical simulations to the real situation as close as possible [6].

- Tests on the global behavior of frameworks conducted within this study with regard to simulation of static column removal should be repeated with consideration of dynamic effects associated with the column removal. This would need more sophisticated measurement devices, more of high-speed visual recording nature that of mechanical nature, including the fast speed video camera and laser technology [8, 10].

- More attention should also be allocated towards researching on innovative constructional details of joints that would enhance the ductile behavior of joints under both hogging and sagging bending, like position of bolts, welding scenarios minimizing the influence of ductility degradation in heat affected zones (HAZs), optimized localization and spacing of shear connectors of composite beams in the neighborhood of beam-to-column joint [7, 8].
• There is a need for continued research on finite element modeling (FEM) of the local and global behavior of frameworks, especially with reference to dynamic situations. Initial investigations presented in this study on the dynamic simulations of static behavior of joints have shown that there is a number of difficulties in terms of numerical stability of the problem solution and early termination of analysis as a result of severe nonlinearities appearing in the finite element formulation of physical phenomena, especially related to modeling of the inelastic behavior and cracking phase of concrete. The physical ductility criteria related to the analysis termination need to be evaluated and implemented so that the final termination point is not referred to the occurrence of numerical divergence but to physical nature of failure reasons [5].

• Investigations carried out in my PhD thesis show that there should be a further research effort undertaken towards the topic of application of the component method for joint properties and joint characteristic evaluations considering both the joint behavior in isolation and its behavior in frameworks, especially in relation to sagging bending and sagging bending associated by membrane state of forces.

4. WORK PLAN

Being at this moment impracticable the establishment with accuracy of a detailed time plan for this project, since it strongly depends on the time availability of the persons and institutions that will be involved, a task plan will be instead presented with the most relevant tasks to be completed in order to achieve the project objectives. Some of these tasks will probably be running in parallel, and it is also intended to publish articles based on this work in international events, journals or magazines, whenever possible. It makes part of the work plan to do (in brackets is the total time expected to be consigned to the task):

1. Literature review and the set up of an articles database. (2 - 3 months).
2. Contact with Professor Marian A. Gizejowski my PhD supervisor, Warsaw University of Technology, Poland to get from his experience some details about dynamic behavior of testing the experimental specimen tests (2 - 3 months).
3. Study of ABAQUS static and dynamic analysis and creating a virtual simulation environment where to build the model of a first machine to work based on the new principle. (3 - 5 months)
4. Creation of a webpage to open the project to the scientific community and to inform about the results and the advances meanwhile achieved. (3 – 5 months).
5. Tests and experiments in the virtual prototype and the documentation of results. This is expected to lead to the publication of at least one article in an international event, journal or magazine, and therefore includes the time needed to write the Post-doctoral proposal. (8 -12 months).
6. Articles and probably attend some scientific events and conferences. (6 – 8 months).

The minimum period to get the job done is 24 months and, the maximum to complete the whole work around 36 months.

7. REFERENCES


[2] B. Saleh, Robustness Assessment of Local Behavior of Flush and Extended End-Plate Joints In Steel-Concrete Composite Frameworks, International Conference on Civil, Urban and Environmental Engineering, 2014, Beijing, China


[10] B. Saleh, Moment-Rotation Characteristic of Joints of Steel-Concrete Composite Frame under Exceptional Events, IABSE Nara, Japan 2015.