

COST ACTION TU0601
Robustness of Structures

Minutes of the Working Group 3 (WG3) Meeting

Coimbra, Portugal, March 2-3 2009.

Attendance

Dimos Charmpis	CY
Marios Chryssanthopoulos	UK
Luis Canhoto Neves	PT
Selcuk Toprak	TR
Boulent Imam	UK
Jitendra Agarwal	UK
Mehmet Inel	TR
Fabio Casciati	IT
Lucia Faravelli	IT
Sara Casciati	IT
Daniel Honfi	SE
Harikrishna Narasimhan	CH
Joan Raman Casas	ES
Victoria Janssens	IE
Aleksander Kozlowski	PL

The Action Rapporteur Kiril Gramatikov was also present at the WG3 meetings.

Documents prepared and distributed since last meeting

- D. Diamantidis, "Robustness of structures in codes of practice"
- J Agarwal, "Robustness of rc buildings under seismic loads"
- S Thelandersson and D Honfi, "Structural behaviour of timber structures with reference to robustness"
- M Inel, "Concrete buildings subjected to earthquakes in Turkey"

Presentations at the Coimbra meeting

The following presentations, directly related with WG3, were given:

- D Honfi, "Robustness of long span buildings"
- M Inel, "Analysis of damage/collapse statistics from concrete buildings under seismic loads"
- J Agarwal, "Methodology for extracting robustness information from damaged/collapsed buildings under seismic loads"
- B. Imam, "Probabilistic robustness assessment of steel bridges"
- S Toprak, "Vulnerability assessment for pipelines"

- M Chryssanthopoulos, “Report on current state and progress of work in WG3”

Activity 6 – Safety measures

a. *Classification of importance classes*

The basis will be taken from Eurocode 1 – Accidental Actions (EN 1991-1-7), which covers buildings and bridges, and will be extended also for other types of structures. A possible classification according to the ratio of indirect to direct consequences will be investigated.

National initiatives will be included in this activity, in particular possible links with current efforts in Italy (Casciati/Baratono) and UK (IStructE) to better define and describe robustness need to be captured.

b. *Classification of safety measures*

A possible classification according to RAPS (Resist – Avoid – Protect – Sacrifice) has been discussed in earlier meetings. Also, a distinction between structural measures, functional measures and organizational measures (affecting human errors) has been considered. It was envisaged that a note on organizational measures affecting human errors (O. Lagerqvist) and a proposal for a matrix classification of safety measures (D. Diamantidis) would be available in Coimbra. As the two authors were unable to attend, this remains an action for the next meeting

c. *Effect of monitoring/smart technologies*

Robustness can be enhanced through state-of-the-art technologies, including monitoring, smart structures, self-healing materials etc. Since WG3 is focused on possible improvements of robustness, it is felt important to consider this topic through an increased awareness of what is being proposed in US and elsewhere. S Casciati and L Faravelli have offered to take this forward.

Activity 7 – Consequence analysis

The different factors affecting consequence analysis (system definition, timeframe, etc.) have been pointed out during the discussions. Special emphasis has been given in distinguishing between direct and indirect consequences. Chryssanthopoulos presented an analysis of the I35-W collapse, as an example of tracking direct and indirect consequences. Neves pointed out the work by Frangopol on bridge networks. Imam presented a methodology for determining the robustness index of steel bridges under different hazard scenarios. The fact that the robustness index will be affected by deterioration was emphasized. As a result, the robustness index for bridges is a time-varying quantity.

Activity 8 – Case studies

The case studies envisaged in the previous meeting have been developed further; in particular, presentations and discussion on the following two took place during the meeting:

1. Buildings with long spans (prepared by D Honfi / S. Thelandersson)
2. Concrete buildings subjected to earthquake (prepared by J. Agarwal, S. Toprak and M. Inel)

The aim of these studies is to illustrate causes and consequences, as well as possible measures for robustness improvement. Analysis of damage collapse of buildings will be developed further with the aim of understanding positive and negative factors affecting robustness. In order to avoid duplication of effort, it is important to focus on single buildings, particularly those that should be expected to possess a degree of robustness (schools, hospitals, public buildings). Inel and Agarwal will work together on developing these ideas into a database for rc buildings. We are particularly interested in cases where the quality of construction has not been the determining factor in damage/collapse.

On the long span buildings, it was proposed to develop further the study presented by Honfi, particularly with respect to connection issues and with respect to systematic/non-systematic human errors. The latter to be linked with the work proposed by Lagerqvist.

Themes of work for next meeting:

- Robustness requirements / criteria in codes, regulations and best-practice guides [Diamantidis, F Casciati/Baratono, Chryssanthopoulos]
- Consequence modelling:
 - Analysis of damages/consequences in selected mid-rise buildings through EQ databases; identification and categorisation of positive and negative features; emphasis on public buildings [Inel, Agarwal]
 - Analysis of consequences from bridge failures [Imam, Neves, Chryssanthopoulos]
 - Long-span buildings [Honfi / Thelandersson / Lagerqvist]
- Improvement of Robustness through monitoring and smart materials/devices [S Casciati, Faravelli]
- Contribution to the example defined by WG2 – to be defined

General remarks

- The interaction with WG1 (General methodology) and with WG2 (Exposures and human errors) is necessary at this stage.

- WG3 members are kindly asked to send their deliverables to the working group leader (M. Chryssanthopoulos) at least one week before the next meeting.
- Avoid duplication of effort – information exchange with C26 was strongly recommended by the action's Reporter.