



## JRC TECHNICAL REPORTS

# Summary of the meeting on 11 December 2015 on adaptation of structural design to climate change

*Support to the implementation, harmonization and further development of the Eurocodes*

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2016

**Eurocodes** ▶

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# MEETING ON IMPLICATIONS OF CLIMATE CHANGE ON STRUCTURAL DESIGN

11 December 2015, 9:30 – 17:00, meeting room of building 48, JRC, Ispra, Italy

(in the framework of the AA between JRC and DG GROW on support to policies and standards for sustainable construction)

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## 1. Participants

1. **Paolo Formichi**, Convenor CEN/TC 250/SC10 “Basis of Structural Design”, University of Pisa, Italy
2. **Pietro Croce**, Convenor CEN/TC 250/HG “Bridges”, University of Pisa, Italy
3. **Nikolaos Malakatas**, Chairman CEN/TC 250/SC1 “Actions on structures”, Ministry of Transports, Infrastructures and Networks, Greece
4. **Paola Mercogliano**, Centro Euro-Mediterraneo sui Cambiamenti Climatici, Italy - **apologies**
5. **Maria Noyal**, Trinity College, Dublin, Ireland
6. **Svein Fikke**, Meteorological consultant, Norway, Project Team leader for SC1.T5 “Climate change” under Mandate M/515
7. **Artur Pinto**, Head of European Laboratory for Structural Assessment Unit, JRC, European Commission
8. **Jutta Thielen Del – Pozo**, Acting Head of Climate Risk Management Unit, JRC, European Commission - **apologies**
9. **Manfred Fuchs**, Clean Technologies and Products Unit, DG GROW, European Commission - **apologies**
10. **Miguel George Paunescu**, Adaptation Unit, DG CLIMA, European Commission
11. **Alessandro Dosio**, Climate Risk Management Unit, JRC, European Commission
12. **Silvia Dimova**, European Laboratory for Structural Assessment Unit, JRC, European Commission
13. **Georgios Tsionis**, European Laboratory for Structural Assessment Unit, JRC, European Commission
14. **Luisa Sousa**, European Laboratory for Structural Assessment Unit, JRC, European Commission

## 2. Objectives

1. Discuss the feasibility and needs for creating snow map for structural design which accounts for the climate change:
  - availability of methodology and data;
  - scope of a snow map project – geographic, time span;
  - support / resources needed.
2. Set-up a group to create a document on the rationale and needs for a snow map for structural design which accounts for the climate change.
3. Discuss the interaction with CEN/TC 250 Project Team (PT) on SC1.T5 (the Project Team on the CEN report on adaptation of the Eurocodes to the climate change, Task 5 of SC1, under Mandate M/515).
4. Identify other actions on structures to consider:

- important phenomena / actions;
- ranking of actions on structures to consider;
- proposals of relevant experts to join the network.

The programme of the meeting is presented in Annex 1.

## 3. Summary and conclusions

### 3.1 State of progress

#### 3.1.1 EU policies and actions relevant to climate change adaptation

The climate is changing, despite the mitigation efforts. The EU is already facing unavoidable impacts, some of which have cross-border dimensions. Effective adaptation actions can reduce overall damage costs, save lives, and natural and human assets. The EU Strategy on adaptation to climate change<sup>1</sup> establishes an EU-wide framework to support adaptation measures that have to be designed and applied locally. The European Structural and Investment Funds as well as Horizon 2020 and the LIFE programme provide significant support to programmes and projects on adaptation to climate change.

One of the key priorities of the Strategy is the infrastructure, which needs to withstand the current and future impacts of climate change. Building on the Mandate M/515<sup>2</sup> of the European Commission to CEN to assess the climate change implications for the Eurocodes, further work with standardisation organisations, financial institutions and project managers should analyse to what extent standards, technical specifications, codes and safety provisions for physical infrastructure should be strengthened to cope with extreme events and other climate impacts.

The Mandate M/526<sup>3</sup> requests the European Standards Organisations (ESOs) to contribute to building and maintaining a more climate resilient infrastructure throughout the EU in the three priority sectors: transport infrastructure, energy infrastructure, buildings/construction, plus ICT infrastructures that are closely interconnected with, and support the functioning of the physical infrastructure. By the end of 2016 the list of standards to be revised with priority will be ready.

The activities of the JRC Climate Risk Management (CMR) Unit address the observation, evaluation, anticipation and communication of the impacts of current weather extremes and future climate change, and the evaluation of the effectiveness of policies and measures that reduce their risks. The JRC European Laboratory for Structural Assessment (ELSA) Unit conducts pre-normative research towards European standards for safety and security of built environment, addressing also sustainability and efficiency issues. The JRC ELSA Unit is involved in adaptation of structural design to

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<sup>1</sup> COM(2013) 216 final. An EU Strategy on adaptation to climate change.

<sup>2</sup> M/515 EN, 2012. "Mandate for Amending Existing Eurocodes and Extending the Scope of Structural Eurocodes", DG Enterprise and Industry, European Commission, Brussels, 12 December 2012.

<sup>3</sup> M/526 EN, 2014. Commission implementing decision to make standardisation request to the European standardisation organisations pursuant to Article 10 (1) of Regulation (EU) No 1025/2012 of the European Parliament and of the Council in support of implementation of the EU Strategy on Adaptation to Climate Change [COM(2013)] 216 final, Brussels, 28 May 2014.

climate change in a framework of a three-year programme for Administrative Arrangements with DG GROW. The programme envisages:

- 2015 and 2016: set-up of a scientific network on adaptation to climate change and definition of research needs and opportunities for adaptation of structural design to climate change;
- 2017: technical report on the findings and research needs.

At a working meeting on 2 December 2013 the two JRC Units launched a dialogue between climate change experts, and experts in the fields of structural design and loading on structures in order to delineate the state-of-the-art and the needs (data, research, collaboration) to assess the implication of the climate change on structural design with regard the forthcoming works on the second generation of the Eurocodes. At this meeting a network on implications of climate change on structural design was set-up informally, which continues its interactions by exchange of material and meetings.

### 3.1.2 The Eurocodes and the climate change

The Structural Eurocodes which deal with the design of buildings, infrastructures and civil engineering structures are already implemented within most of the CEN Members, as stated in the recent report of the European Commission on the implementation of the Eurocodes<sup>4</sup>. The climatic data on which the current generation of the Eurocodes is based are mostly 10-15 years old, with some exceptions of recent updates of national data, e.g. the case of the new maps for climatic actions of the Czech Republic.

CEN/TC 250 “Structural Eurocodes” has just started the works on the evolution of the Eurocodes under the Mandate M/515, and the second generation of the Eurocodes is expected by 2020. The standardisation works relevant to the climate change encompass:

- revision and update of EN 1991-1-3 on snow loads, EN 1991-1-4 on wind actions, and EN 1991-1-5 on thermal actions, preparation of background documents;
- conversion of ISO standards on actions from waves and currents, and on atmospheric icing to ISO-EN standards;
- preparing a document with the probabilistic basis for determination of partial safety factors and load combination factors, taking into account the variability and interdependence of climatic actions;
- technical report (TR) by Project Team (PT) on SC1.T5 analysing and providing guidance for potential amendments for Eurocodes with regard to structural design addressing relevant impacts of future climate change (general and material specific).

PT on SC1.T5 intends to make use of the results obtained in ongoing research projects carried out all over Europe and globally. The TR will provide recommendations for modified or additional clauses, and, where appropriate - background documents. The primary focus of the TR will be on the way to incorporate possible climatic change events and actions in the design rules now in order to avoid future expensive structural modifications due to the climate change. The final report of PT on SC1.T5 shall be delivered by April 2017.

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<sup>4</sup> State of implementation of the Eurocodes in the European Union, authors S. Dimova, M. Fuchs, A. Pinto, B. Nikolova, L. Sousa, S. Iannaccone, EUR 27511, doi:10.2788/854939, 2015.

### 3.1.3 Pilot study on snow loading map for structural design

It is expected that the global warming will reduce the frequency of the snow events. On the other hand, the intensity of extreme snow events may increase, since the capacity of the atmosphere to hold moisture increases with temperature. This may lead to the increase of both snow density and occurrence of extreme snowfalls in regions where temperatures still may happen to be below freezing level during precipitation events. To assess the evolution of the snow load and its impact on design of new buildings and on reliability of existing ones, a comparison of future trends, in both intensity and frequency of future precipitation in cold areas with current versions of snow load maps for structural design should be performed.

The European Snow Loads Research Project was carried out under contracts with the European Commission DG III – D3 in the period 1996-1999 with the aim to provide scientific basis for harmonised definition of models for determining the actions of snow applied to the structural parts of construction works. The project was led by Pisa University. The snow load design map produced by this project is incorporated in Annex C of EN 1991-1-3 with the aim to help National Competent Authorities to redraft their national snow maps and to establish harmonised procedures to produce such maps.

A pilot study on creating a snow load map for structural design taking into account the climate change was launched at a working meeting on 8 April 2014 at JRC/Ispra with the participation of Pisa University and the JRC CRM and ELSA Units. While the study has been performed in Pisa University, the JRC CRM Unit provided data on climate change projections, and the two JRC Units consulted the approach and the results.

The pilot study encompasses:

- setup of a general procedure to derive snow loads combining meteorological observations and predictions using input data corresponding to the daily output of climate change projections (minimum and maximum temperature  $T_{\min}$  and  $T_{\max}$ , and precipitation  $h_{\text{rain}}$ );
- calibration of the procedure against registered data on ground snow cover and snow density in 9 Italian weather stations;
- preliminary implementation of the procedure extending the data of the 9 Italian weather stations to climate change projections series (scenario RCP4.5 from one model only for the initial test of the process) up to 2100, in order to estimate future trends of characteristic ground snow loads.

The results obtained show that the developed procedure is very appropriate for the creation of snow maps taking into account the climate change implications, since it allows to estimate characteristic ground snow loads on the basis of daily data  $T_{\max}$ ,  $T_{\min}$  and  $h_{\text{rain}}$ , which are typically available as outputs of climate change projections for all possible scenarios.

### 3.1.4 RAIN and INTACT FP7 Projects

The project “Risk Analysis of Infrastructure Networks in Response to Extreme Weather” (RAIN) is an ongoing 7th Framework Programme (FP7) from 2014 to 2017. The project focuses on four types of critical infrastructure (CI): i) roads, ii) railways, iii) electrical power supply infrastructure and iv) telecommunication. The analysis of interviews with stakeholders indicates that CI operators are most concerned about the impacts of freezing precipitation, snowfall, snow loading and snow storms, windstorms and heavy precipitation, especially if the latter lead to river floods. In addition, particular CI types are especially sensitive to a particular type of severe weather that is of lower concern to other types of CI. For instance, telecommunication is very vulnerable to lightning, road

transportation to coastal floods, and rail transportation to landslides. In mid-2016 a deliverable of this project will address the frequency of weather hazards throughout Europe for both the present and future climate up to 2100.

The on-going FP7 project “On the Impact of Extreme Weather on Critical Infrastructures” (INTACT) started in 2014 and will finish in 2017. The project deals with definition and assessment of appropriate extreme weather indicators (EWIs) characterizing the atmospheric critical factors relevant for the different CIs. The research encompasses assessment of past trends of EWIs, projections of EWIs over the 21st century and development of extreme weather (EW) scenarios for case studies, calibrated to the local scale. The INTACT database shows that the most damaging impacts on CIs by EW are mainly due to extreme values of precipitation and wind, but also of other parameters, such as temperature and snow. The assessment of the EWIs over 21st century shows, that most of the temperature indicators have a positive trend. Regions particularly affected by the increases of temperature, especially in the long term period (2071-2100), are those located in the Mediterranean area. The results on precipitation indicators highlight different behavior between northern and southern Europe, especially in the near term period (2011-2040). Wind indicators revealed a non-uniform spatial behaviour over Europe. While almost the whole Europe will be affected by a general reduction of the snow EWIs, the analysis of the snow events with 50-year and 100-year return periods shows different behavior of the snow falls in the north and south of Europe, especially over the long term future period (2071-2100).

## 3.2 Conclusions

1. To proceed with adaptation of structural design to climate change, there is need to have estimate of expected changes, made in terms of the Eurocodes concept for the characteristic values of the variable climatic actions as the upper value of a random variable with annual probability of exceedance of 2% (i.e. a “reference period” of 50 years) for future time windows (typically of 30-40 years) up to the end of the available modelled data time period. Such estimates are still not available in the results of the reviewed existing European research projects on impact of extreme weather on the critical infrastructure. These projects are producing valuable estimates which can be used for ranking the priorities in consideration of the climatic actions and extreme events in structural design, for evaluation of further needs for refining the design concepts of most exposed critical infrastructure, and can form basis for future projects on estimation of the characteristic values of the climatic actions for structural design.
2. The procedure developed in the pilot study on snow load is very appropriate for creation of snow maps taking into account the climate change implications, since it allows to estimate characteristic ground snow loads on the basis of daily data for the minimum and maximum temperature and precipitation, which are typically available as outputs of climate change projections for all possible scenarios. A project on such snow map shall be started as soon as possible, in order to have the results before finalizing the works on the second generation of the Eurocodes. Further to the possible update of existing maps in Annex C of EN 1991-1-3 and to the agreement on an harmonised procedure to produce national snow maps in order to reduce inconsistencies at border between neighbouring countries, the produced map will be of guidance for National Authorities in distinguishing potentially critical areas, expected to be subjected to the effects of increasing snow loads, due to climate change effects. The new snow map should encompass all CEN Member countries and other European countries which are, or will be adopting the Eurocodes, e.g. the Balkan countries. To produce such map there is need to set-up a European project with respective funding.



3. Representatives of Pisa University and the JRC, with the support of all members of the network, will create in the beginning of 2016 a document on the rational and needs for a snow map for structural design which accounts for the climate change.
4. Synergy and harmonisation should be sought between the standardisation works relevant to climate change under Mandates M/515 and M/526. These works can be coordinated at ESOs and Commission levels. The CEN/TC 250 representatives at the meeting will inform the Chairman of TC 250 about the start of the works under M/526. DG CLIMA will inform the ESOs Coordination Group on M/526 regarding the opportunities to synchronise their activities with the works of CEN/TC 250 relevant to climate change. The Commission DGs concerned by the works on M/515 and M/526 will continue to exchange views and information on the state of the progress and the strategies for further development.
5. The network on implications of climate change on structural design will act in synergy with CEN/TC 250 SC1 PT on SC1.T5 (the Project Team on the CEN report on adaptation of the Eurocodes to the climate change). The leader of the aforementioned PT is invited to join the network. The JRC is invited to the workshop and PT's meeting on 16-17 February 2016 in Oslo. The views expressed by the leader of PT on SC1.T5 on the future needs and trends for creating of global maps for climatic actions will be taken into consideration by the network when appropriate.
6. Basing on the results of RAIN and INTACT projects on the future trends and impacts of extreme weather events on critical infrastructure, the network will start in 2016 considering the feasibility of creation of a map for wind actions on structures taking into account the climate change. The results of these projects will be further discussed to rank the important phenomena / actions on structures to consider in the design standards. Representatives of RAIN and INTACT projects are invited to join the network and to nominate experts on wind actions for the forthcoming activities of the network in this field.

## Annex 1 – Programme

1. **Welcome and introduction**, *Artur Pinto, HoU ELSA, JRC*,
2. **Background and objectives**, *Silvia Dimova, ELSA, JRC*
3. **EU climate change adaptation policy**, *George Paunescu, DG CLIMA*
4. **JRC activities in climate change risk management**, *Alessandro Dosio, Climate Risk Management Unit, JRC*
5. **Progress in assessment of the implications of the climate change on the snow loading of structures**, *Paolo Formichi, Convenor CEN/TC 250/SC10 “Basis of Design”, University of Pisa and Pietro Croce, Chairman CEN/TC 250/HG “Bridges”, University of Pisa*
6. **Prospect for CEN/TC 250 technical report on the adaptation of the Eurocodes to relevant impacts of future climate change**, *Nikolaos Malakatas, Chairman CEN/TC 250/SC1 “Actions on structures”, Ministry of Transport, Infrastructures and Networks, Greece*
7. **Results from FP7 INTACT Project relevant to impacts of climate change on structural design**, *Paola Mercogliano, Centro Euro-Mediterraneo sui Cambiamenti Climatici, Italy: presented by Alessandro Dosio, JRC*
8. **Results from FP7 RAIN Project relevant to impacts of climate change on structural design**, *Maria Nogal, Trinity College, Dublin*  
*Lunch break*  
*Visit of ELSA laboratory (optional)*
9. **European climate maps for actions**, *Svein Fikke, Meteorological consultant, Norway, Project Team leader for SC1.T5 “Climate change” under Mandate M/515*
10. **State of harmonisation in defining the climatic actions in the Eurocodes National implementations**, *Silvia Dimova, ELSA, JRC*
11. **Round table discussion** on further steps needed for adaptation of structural design to climate change, *all participants*

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