



**European Commission
Research Programme of the Research Fund for Coal and Steel**

ANGELHY

**Innovative solutions for design and strengthening of
telecommunications and transmission lattice towers using large angles
from high strength steel and hybrid techniques of angles with FRP
strips**

WORK PACKAGE 5 – DELIVERABLE 5.3

Dissemination and Webinar

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National Technical University of Athens - NTUA, Greece

Beneficiaries:

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Université de Liège - ULG, Belgium

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1 Introduction

Originally, it was foreseen to organize a physical workshop with experts from design offices in the domain of lattice towers and lattice tower fabricants.

Due to the COVID-19 pandemic, the physical workshop was transformed into a virtual webinar. The workshop was organized by ArcelorMittal Belval & Differdange with support from the Research Association for Steel Application (FOSTA) in Germany.

FOSTA sent invitation for the webinar within its network and reached named experts in the domain of steel lattice towers. With support from FOSTA two additional presenters from RWTH Aachen were recruited and in this way the scope of the webinar was even extended.

The webinar finally took place on 8th December 2020 via the platform Zoom under the presentation of ArcelorMittal Belval & Differdange.

2 Organization of the webinar and summary of the event

In preparation of the webinar, several promotion activities took place.

A flyer (Figure 2.1) with the description of the topic and the agenda has been prepared and uploaded on the homepages of the different institutions/companies of the partners.

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ANGELHY
Innovative solutions for design and strengthening of telecommunications and transmission lattice towers using large angles from high strength steel and hybrid techniques of angles with FRP strips

Webinar/Workshop
08 | 12 | 2020
Innovative developments in the field of steel lattice towers
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PROGRAMME

<p>ANGELHY</p> <p>Steel lattice towers are extensively built in Europe and worldwide to serve telecommunication or power transmission purposes. Such towers are often installed in mountainous terrain with very limited access to heavy vehicles. Their members are frequently composed of equal leg angle sections that are preferred to tubular sections due to their easier connection that results in a simpler erection. Angles sizes range from light to heavy sections with leg lengths up to 300 mm that are lately produced in Europe and are employed for towers with increased height. The use of high strength steel in lattice towers results in smaller member cross sections and further structural weight reduction.</p> <p>The workshop informs on the latest research results in the field of steel lattice towers followed by presentations on current technical innovations in steel towers based on results from steel applied research.</p> <p>The workshop comprises a critical view on the current design standards for steel lattice towers, the presentation of new and economic design rules for single angle and built-up members, the strengthening of members of lattice towers by introducing carbon fiber reinforced polymers (CFRP) strips and a performance-based approach for estimating the reliability of steel lattice towers. In addition to the presentations, design recommendations for steel lattice towers and for the application of the CFRP strips will be given.</p> <p>The event is targeted at experts from research and practice. It includes building authorities, design offices, suppliers of electric energy, telecommunication providers, steel producers, steel fabricators, and representatives from researchers and development as well as federations.</p> <p>The event is organized in the framework of the EU-research project ANGELHY and it is financially supported by the research Fund for Coal & Steel (RFCS).</p> <p>Ideal support from </p>	<p>10:00 Welcome Prof. I. Vayas, NTUA, Athens; M. Tibolt, AMBD, Luxembourg</p> <p>10:10 EU-Research project ANGELHY Prof. I. Vayas, NTUA, Athens</p> <p>10:30 Case study design – Transmission tower M. Tibolt, AMBD, Luxembourg</p> <p>10:50 New rules for single and built-up angle members M.Z. Bezos, Université de Liège, Liège; A. Beyer, CTICM, Saint-Aubin</p> <p>11:20 Hybrid angle members - CFRP materials – Design rules S. Reygner, Sika France, Le Bourget; K. Vlachakis, NTUA, Athens</p> <p>11:35 Risk assessment of lattice towers Prof. D. Vamvatsikos, NTUA, Athens; D. Billonis, NTUA, Athens</p> <p>11:50 Design tool for steel lattice towers M. Friehe, RWTH Aachen, Aachen</p> <p>12:10 Wind loads on steel lattice towers Prof. F. Kemper, RWTH Aachen, Aachen</p> <p>12:30 Discussion and Closure of Workshop at 13:00</p>
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Figure 2.1: Flyer of the workshop

A specific column has been uploaded on the homepage of ArcelorMittal Construction S.A to advertise the webinar among the customers of ArcelorMittal. In addition, the column contained links to the institutions of the project partners with additional information on project ANGELHY.

Moreover, the event was announced on Twitter and LinkedIn.

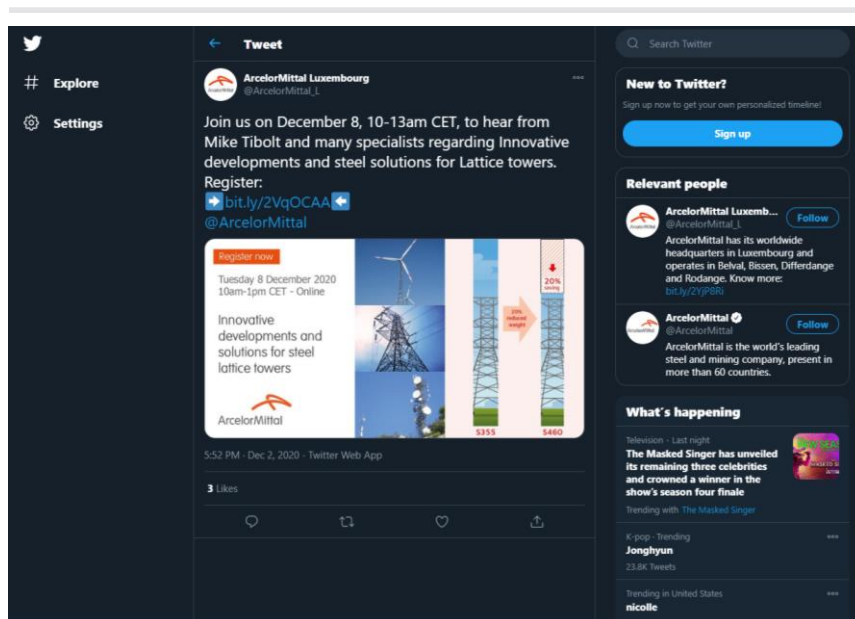
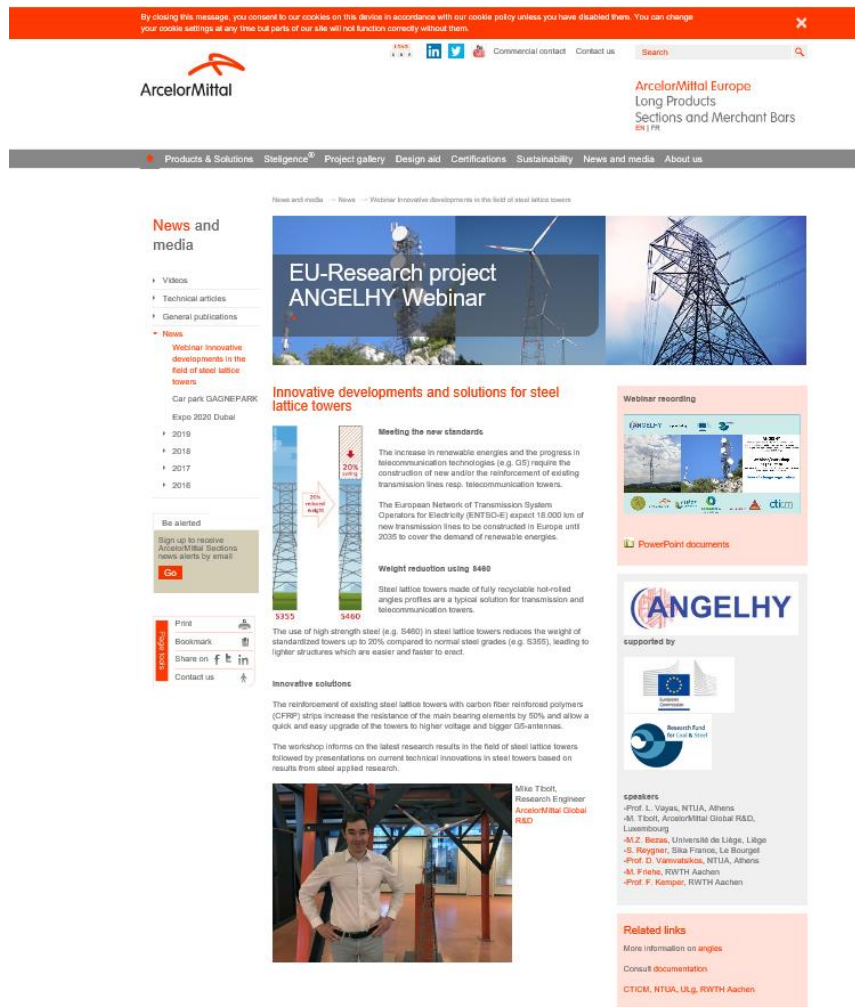


Figure 2.2: Advertising of the workshop
 (https://sections.arcelormittal.com/News_and_media/News/5208/EN)

Invitations have been sent by all partners and FOSTA to dedicate engineering offices and experts in the design and fabrication of steel lattice towers within Europe and even outside Europe.

Finally, 262 registrations to the webinar were noted. Table 2.1 resumes the list of attendances. The attendances came from 27 different countries: Luxembourg, Greece, Belgium, France, Germany, The Netherlands, UK, Portugal, Spain, Italy, Rumania, Albania, Moldova, Czech Republic, Poland, Norway, Estonia, Denmark, Israel, Tunisia, Morocco, US, Canada, Brasil, India, Saudi Arabia, United Arab Emirates.

Table 2.1: Attendance

Attendance	Number of registrations
Engineering offices	93
Academics	68
Steel fabricators	9
Consultants	15
Architects	7
General contractors	1
Real estate investors	2
Others	67
Total	262

The webinar started on 8th December 2020 at 10:00 and ended at 13:00. During the presentations, the participants had the possibilities to write questions to the presenters. The questions were all answered in written form during the presentations and orally during the discussion round at the end of the webinar by the project partners.

A list with the questions and answers is given in Table 2.2.

Table 2.2: Summary - Question and answers

Nr.	Question	Answer
1	EN 50341-1, which one? 2001 or 2012?	It is EN 50341-1:2012 and the corresponding National Annexes
2	Which national annexe has been retained?	The case study design was done acc. the German National Annex. So the German National annexe was retained in this project
3	Are the steel angles cold-formed or hot-rolled?	The profiles are hot-rolled

4	I noticed that the formulation presented on the Eurocodes were considered to compare with the project outputs. However, there is an American code that is specific for the design of transmission towers (ASCE 10-15). Is there any expected provision of a new European standard for this topic?	We concentrated in the project on the Eurocodes because it is a European funded projects. But you are right and also a comparison needs to be done to the American standards. This will be done apart from the present project.
5	Formulaes in EN 1993 do not provide mean values but design values (roughly mean minus 3 sigmas)	In the presentation currently running you can see that the final comparison is done in terms of reliability, i.e., by accounting for mean versus characteristic values to ensure consistent safety factors are applied. On one-to-one terms, it is indeed not easy to compare, but still useful to make sure that at least some conservative margin is present. How conservative the margin is, becomes a different question.
6	In the segmental analysis, was there triangulated hip bracing between the two diagonal members?	Yes there were bracing members
7	In the built up section test, is the compression load applied uniformly at the end of the built-up section?	For BBE and SBE specimens the loads are applied through the common centroid. For SBU specimens the axial load is applied through the centroid of the taller section. Therefore, SBU have been tested in compression and bending.
8	Is it possible to achieve an Sa2.5 surface finish through wire brushing? Sand blasting in situ can be difficult at height.	It is under investigation which surface finish can be achieved with different methods. The best solution would be to avoid sand blasting on construction site.

9	CarboDur is composed by unidirectional fiber carbon reinforced composite strip, for this reason the carbon fibers shall be disposed on the direction of the axial loads. In some situations, this could lead buckling problems, since compression resistance on the perpendicular direction of the CFRP strip can be limited. Did you include bidirectional carbon fiber composites in your study?	I confirm that only unidirectional laminates were used. It was the best compromise to fit with steel angle members dimensions. It is also easier to apply on job sites rather than bidirectional strips that you need to impregnate before putting in place. For experimental tests, we decided to add CFRP strips at each end of laminates in order to avoid debonding or the creation of a buckling point.
10	Has the project considered the effect of the tower deflecting under wind loading making the compression leg/legs bending nominally inwards forcing different buckling modes and do you think this contributes to the difference between member axial compression tests and tower testing?	The wind loads are applied at the nodes. The checks are performed according to DIN EN 1993-3-1 (i.e. Annex H) based on these internal forces. So not based on buckling modes. Using EN 1993-3-1 the determination of buckling modes is not necessary. But I think / know that it will make a difference. I have checked it exemplarily. In most cases, using the EC is conservative.
11	Do you know how the lattice wind tunnel test results compare to the directional coefficients in EN 1993-3-1 Annex B?	Yes we have compared the results with Annex B. There are differences. Just give me an Email if you need more details.
12	We have lost a bit Mr. Kemper's audio about introduction to wind speed maps vs. weather stations data. Could you please verify in which circumstances EC allows us to use site-specific wind speed prediction based on historical wind data instead of a wind map from an Annex?	In general, you can always use site-specific data to improve upon the National Annex. Of course, at the same time, you assume responsibility for it being accurate and representative.

13	Would it be sufficient to demonstrate the reliability of our own basic wind speed prediction if we report all our steps (i.e. extreme-value analysis) in the calculation?	Live answered
14	I was wondering if you experts have some info about using eiffelized angles for lattice masts with triangular plan. any document? any supplier?	Live answered

The webinar was recorded, and all participants have access to the presentations and the video of the webinar. The presentations and the video can be downloaded under the following link:

https://sections.arcelormittal.com/News_and_media/News/5208/EN

3 Feedback

In the aftermath of the webinar, the participants had the possibility to fill out a questionnaire to give feedback online.

The evaluation of the feedback is given below:

1. What is your general satisfaction with the webinar?

-3	-2	-1	0	+1	+2	+3
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2. What is your opinion on the innovative content?

-3	-2	-1	0	+1	+2	+3
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3. What is your opinion on the technical content?

-3	-2	-1	0	+1	+2	+3
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4. Where you satisfied with the answers given during the webinar?

-3	-2	-1	0	+1	+2	+3
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5. Would you follow a second webinar on the topic organized in the same way?

No (10)	Yes (54)
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6. General comments and improvements
 - a. The results from the experimental campaign should also be compared to EN 50341 and not only to EN 1993-1-1 and EN 1993-3-1
 - b. Allow oral questions after each presentation
 - c. Physical workshops should be organized again
 - d. The results and investigations should be extended to steel lattice towers for wind turbines.

Legends:

- +3 Excellent
- +2 Very good
- +1 Good
- 0 No opinion
- 1 Bad
- 2 Very Bad
- 3 Insufficient

In total, 64 attendances participated to the questionnaire. The results for questions 1 to 4 are given as an average and absolute values are given for question 5.

4 Publications

Several publications have been accepted for the EUROSTEEL conference that will take place in Sheffield, UK, on 1st to 3rd of September 2021:

- Tibolt M.; Bezas M.Z.; Jaspert J.-P.; Demonceau J.-F.: The design of a steel lattice transmission tower in Central Europe. EUROSTEEL conference. EUROSTEEL 2021 conference. Sheffield. To be published.
- Bilonis D.; Bezas M.Z.; Tibolt M.; Vamvatsikos D.; Vayas I.; Performance-based assessment of a steel lattice power-transmission tower: A case study in Germany. EUROSTEEL conference. EUROSTEEL 2021 conference. Sheffield. To be published.
- Vayas I.; Jaspert J.-P.; Bureau A.; Tibolt M.; Kurz S.; Papavasiliou M.: Telecommunication and transmission lattice towers from angle sections – the ANGELHY project. EUROSTEEL conference. EUROSTEEL 2021 conference. Sheffield. To be published.
- Vlachakis K.; Reygner S.; Tibolt M.; Vayas I.: Experimental investigations on rolled angles sections reinforced with CFRP plates. EUROSTEEL conference. EUROSTEEL 2021 conference. Sheffield. To be published.

In addition, two publications have been issued for International Conferences in 2019:

- Bezas M.Z.; Tibolt M.; Jaspert J.-P.; Demonceau J.-F. (2019): Critical assessment of the design of an electrical transmission tower. 9th International Conference on Steel and Aluminum Structures. Bradford.
- Bilonis D. and Vamvatsikos D. (2019): «Wind Performance Assessment of Telecommunication Towers: A Case Study in Greece», Proceedings of the 7th International Conference on Computational Methods in Structural Dynamics and Earthquake Engineering (COMPDYN 2019), Crete Island, Greece, June 24-26, 2019.

5 Codification activities

The partners are active in the following working groups for the revision of the standards:

- CEN/TC 250/SC 03
- CEN/TC 250/SC 03/WG 1
- CEN/TC 250/SC03/WG 14

The partners presented the research results to the above-mentioned working groups to ensure the implementation of the new design rules in the standards.

An official letter (Figure 5.1) signed by all partners has been sent to the Chairwoman (Prof. Ulrike Kuhlmann) of CEN/TC 250/SC 03 to define a roadmap for the implementation of the rules in the standards. The contact with the Chairwoman and the definition of a strategy for the implementation of the rules are essential with regards to the late stage of the standard revision.

Further details on the codification activities can be found in Deliverable 5.1 and 5.2.



Figure 5.1: Official letter to Chairwoman of CEN/TC 250/SC 03 (Prof. Kuhlmann)