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COMBINE USE OF NDT/SDT METHODS FOR ASSESSMENT OF STRUCTURAL TIMBER MEMBERS

Editors:
José Saporiti Machado and Mariapaola Riggio

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Assessment of damaged timber structures using proof load test-experience from case studies

Kiril Gramatikov[1], Toni Arangjelovski[2] and Marija Docevska[3]

[1] Prof. Ph.D., University "St.Cyril and Methodius"-Skopje

[2] Assistant Prof. Ph.D., University "St.Cyril and Methodius"-Skopje

[3] Ms.C. student, grad.civ.eng., University "St. Cyril and Methodius"-Skopje

Introduction

Assessment of the timber structures in R.Macedonia follows the procedure where proof load test was used to verify the available stress state and serviceability state of deflections. This procedure is given in the national standard MKS U.C9.300/1984 [1]. The knowledge and experience in the field of assessment of new and existing or damaged structures, gained from the past years gives us enough data to harmonize behaviour of existing structures according to the standard EN1995-1 as a special case of assessment known as design code assessment.

For example the standard ISO13822 [2] gives instructions that structures designed and constructed based on earlier codes may be considered safe to resist loads if there is no evidence of significant damage, distress or deterioration, planned maintenance ensures sufficient durability and structure has demonstrated satisfactory performance for sufficiently long period of time for displacements.

Despite this fact, for two case studies we have performed structural reliability verification, on the basis of the proof load test results. For this purpose we have used Level 3: Advanced Model Based Assessment given in Annex A of SAMCO F08a Guideline for the Assessment of Existing Structures [3]. Structural reliability analysis was performed for:

- Glued laminated timbers Structure, Cambered beam span of L=24.00m Brewery-Skopje
- Glued Laminated Pedestrian Timber Bridge in Struga, Two-hinged arch, span of L=26.00m plus two simple supported beams span of L=12.5m each.

For these structures design documents and data from serviceability test after observed damage and after construction by proof load test were available [4, 5 and 6].

The semi-probabilistic approach was used based on limit state principle to define partial safety factors. The targeted reliability level for the ultimate limit state and serviceability limit state was defined using the table C.1: Target reliability indices for assessment of existing structures [3].

For ultimate limit state reliability index β was set to β=4.27, for design working life (e.g.50 years) and for high consequences and probability of failure $P_f=10^{-5}$. For the irreversible serviceability limit state reliability index β=1.5 for the remaining working life and probability of failure $P_f=10^{-1}$. These values are the same as given in the Eurocode EN1990.

Reliability verification was done using the Reliability Based Code Calibration program "Code Call" developed by Joint Committee on Structural Safety [7, 8].

Case study: Cambered beam L=24.90m, Brewery Skopje

First structure analyzed in this study is a roof glued laminated timber structure constructed for the Coca-Cola section of Brewery-Skopje, shown in figure 1. The structure is consist of cambered glued laminated timber beams, span of 24.00m, with curved intrados in the middle of the span, 6° slope on the extrados and 4.5° slope on the intrados.

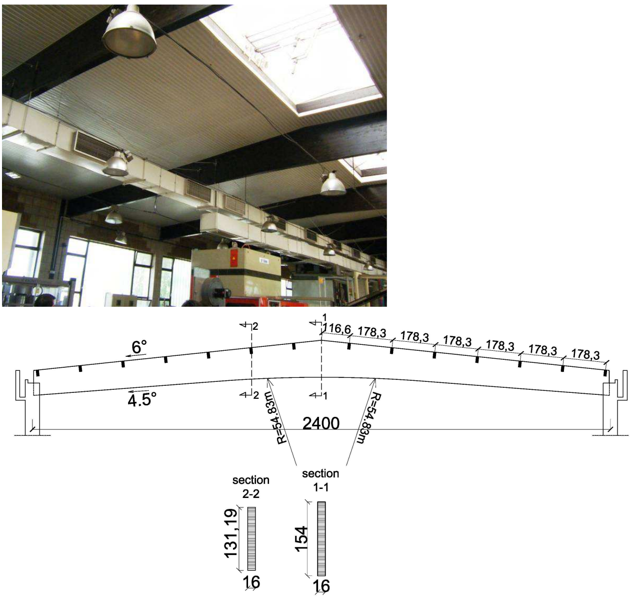

Fig. 1. Industrial building of Coca Cola section, Brewery Skopje

One year after the construction, cracks parallel to the grain direction were appeared at the middle of the height where cambered beam is joined with the steel bracing near the supports. To obtain the accurate state of the stresses and deflections, of damaged cambered beam, proof loading test was performed. The structure was loaded in ten different phases, but in this paper we have analyzed only the ninth phase, in which the test load simulates approximately 90% of the full value of snow load.

The reliability index β was calculated for different values of partial safety factor for the material γ_M (1.0; 1.10; 1.20; 1.30). The results are given in Figure 2. Reliability index β for γ_M=1.20 and ratio between variable and total stresses α=0.74 (for this case) is 4.71. It means that probability of failure for β=4.71 is $P_f=10^{-6}$.

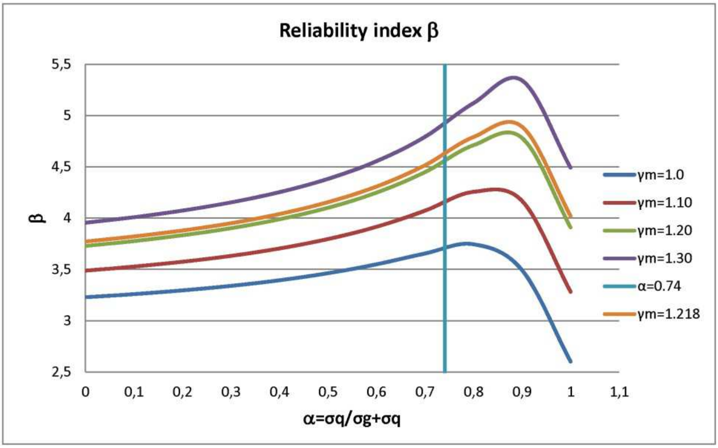

Fig. 2. Reliability index β for different values of γ_M as a function of stresses ratio α

Case study: Pedestrian Bridge over Crn Drim River, Struga

As a second case study in this paper, assessment of existing glued laminated pedestrian bridge over Crn Drim River in Struga was analyzed (Figure 3). The bridge is consist of two parallel main beams which are composed as two-hinged arch beams with span of 25.70m and two single supported beams with span of 12.50m on both sides of the arch as access ramps.

Proof load test was performed for variable load of $5KN/m^2$ which corresponds to design variable load. The test load was set in three unsymmetrical and four symmetrical phases of loading. We were considering only the two phases for which we obtaied maximum measured deflections.

The reliability index β was determined for the coefficient α=0.84 according to the measured deflections from the permanent and variable load. For this value of α, reliability index β=1.50 was obtained as shown on the figure 4. For this value of β, the probability of failure P_f is 10^{-1}.

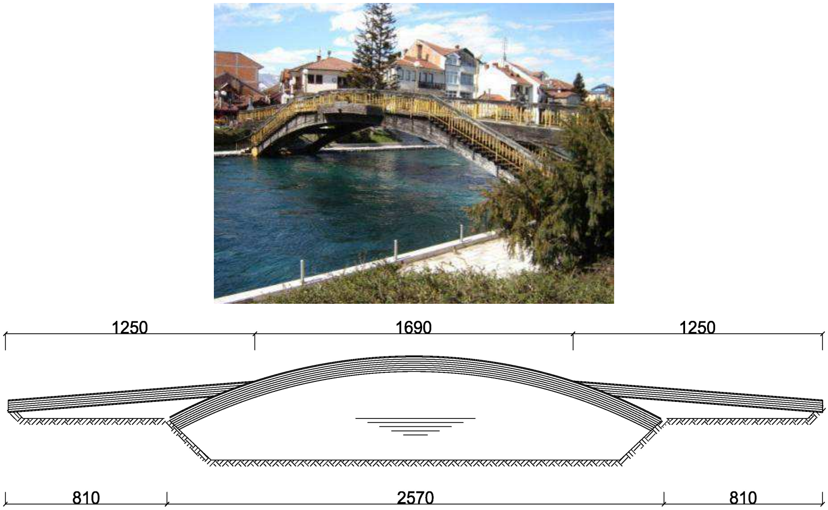

Fig. 3. Two hinged arch pedestrian bridge over Crn Drim river in Struga

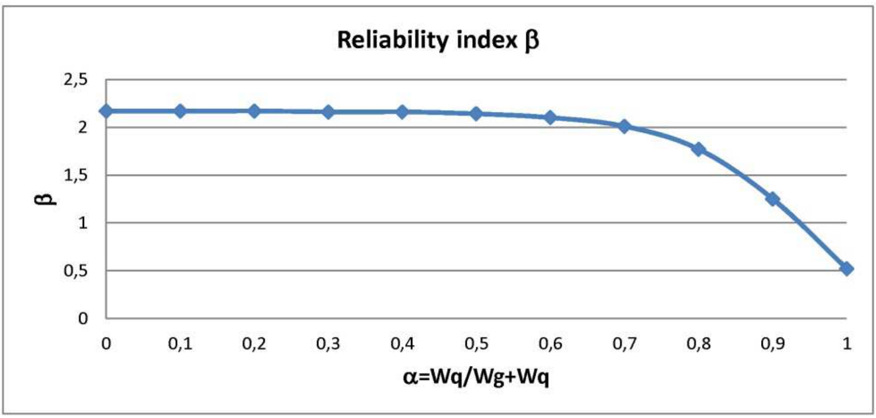

Fig. 4. Reliability index β for irreversible serviceability limit state of deflection for different values of α

Conclusion

From the results of reliability verification analysis, for the two cases of structures, following issues can be concluded:

- For the two type of structure, the special case of assessment new code assessment EN1995 can be applied using Level 3: Advanced Model Based Assessment.
- Analysis of ultimate limit state for the cambered beam L=24.00m, for the ratio of stresses α=0.74, reliability index β was calculated β=4.27 for value of partial factor for the materials γm=1.2 and for the loads γG=1.35 and γQ=1.5.
- Proving irreversible serviceability state of deflections in the case of the pedestrian bridge, two-hinged arch, span of L=26.00m, reliability index was obtained β=1.5, for the given value of de-flections according to serviceability test after construction.
- Structures designed and constructed by the old codes, which during the serviceability period have satisfactory behavior also fulfill the design criteria according to Eurocode EN1995.

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