ASSESSMENT OF TORNADOS
WITH THE ENHANCED FUJITA SCALE IN ROMANIA

C. NUCUŢĂ [1], C. TIMIŞ [2], C. BUŢIU [3], O. SCRIDONESI [1]

ABSTRACT. Assessment of tornadoes with the Enhanced Fujita Scale in Romania. An analysis of the damage caused by a tornado, in order to determine the maximum wind speed that was reached, is important both in terms of documenting the phenomenon and to make improvements to the evaluation method which is used, especially if this method is not specific for the analyzed territory. An overview of the way the tornado from Silivaşu de Câmpie, on the 26th of May 2010, was termed EF2 is done to summarize the difficulties that arise in the assessment of tornadoes occurring in Romania with the Enhanced Fujita scale. The lack of correlation between damage indicators, different construction styles and building materials between those in the United States and those selected in this case study are the main issues addressed. Solutions for these issues are discussed as a starting point for the adjustment of Enhanced Fujita scale for Romania.

Keywords: Tornado, Evaluation, Enhanced Fujita Scale, Silivaşu de Câmpie.

1. INTRODUCTION

On 26 May 2010, in the Silivaşu de Câmpie village, located at the southernmost end of Bistriţa-Năsăud country, on account of severe convective activity, there was a tornadic storm that generated a tornado labeled on the Enhanced Fujita tornado assessment scale with the maximum wind speed of about 201.16 to 217.26 km/h, equivalent to an EF2 (Buţiu C. and Nucuţă C., 2010). In conducting the evaluation there have been encountered a number of issues based on the difference between the U.S. and the Romanian buildings. The main purpose of this article is to present the problems that occurred. Of course, finding possible solutions to this situation is important, but for the moment solutions are left on the background because there are currently not enough people with experience in using this methodology in order to propose viable solutions. Motivated by a desire to overcome this stage, we are determined to make further assessments of tornadoes, so that in future we can propose solutions to bring changes to the Enhanced Fujita Scale so that it can be applied precisely in our country. For this goal to be achieved, a collaboration between people specialized in the field of meteorology and civil engineering is absolutely necessary.

[1] "Babeş Bolyai" University, Faculty of Geography, 400006 Cluj-Napoca, Romania,
e-mail: calinnucuta@gmail.com;
[2] "Politehnica" University, Faculty of Constructions, 400114, Cluj-Napoca, Romania;
[3] "Babeş Bolyai" University, Faculty of Physics, 400084 Cluj-Napoca, Romania

2. ASSESSMENT OF THE TORNADO EVALUATION WITH THE ENHANCED FUJITA SCALE

In any analysis of such extreme weather, accurate determination of its intensity is vital. To determine what wind speeds are reached in a tornado, the Fujita scale was used. It was introduced by Dr. Ted Fujita and it is based on observations on the damage the wind in a tornado has done. In June 2004 the department of Wind Science and Engineering Center in the Texas Tech University proposed a new scale for measuring tornados intensity, more complex, derived from the old Fujita scale. When using the Enhanced Fujita Scale there are considered certain damage points of the affected area, known as damage indicators (DI). For every damage indicators there is assigned a certain estimated wind speed, depending on their degree of destruction (DOD). If there are elements of the damage indicators (construction materials, technical quality or age) that could increase or weaken the structural strength, there is an upper and a lower limit of wind speed, between which, the assessor may increase or decrease the average speed, for that degree of destruction. The highest wind speed of a damage indicator will set the rating of the tornado.

In our tornado evaluation case study, following investigations on the ground added with the witness accounts, it was concluded that the tornado passed through the villages Silivaşu de Câmpie, Urmeniş, Fînaţe and Câmp. It had a trail of about 7,2 km and a lifetime of about 20 minutes between 17:40 P.M. and 18:00 P.M. local time. It touched the ground in the west of Silivaşu de Câmpie, travelled roughly parallel to the main road through a park of the village, it crossed the national road, DN 16, at the 37th kilometer, and went in the forest in the northeastern part of the village, in the area were the greatest damage was done. Furthermore, there are descriptions of local authorities which state that minor damage to the roofs of some houses and some barnes are also found in several villages east of Silivaşu de Câmpie: Urmeniş, Fînaţe and Câmp.

For the evaluation of this tornado we considered six damage indicators, represented on a map in Fig. 1, representative because they are areas with the highest values of the damage from the tornado path.

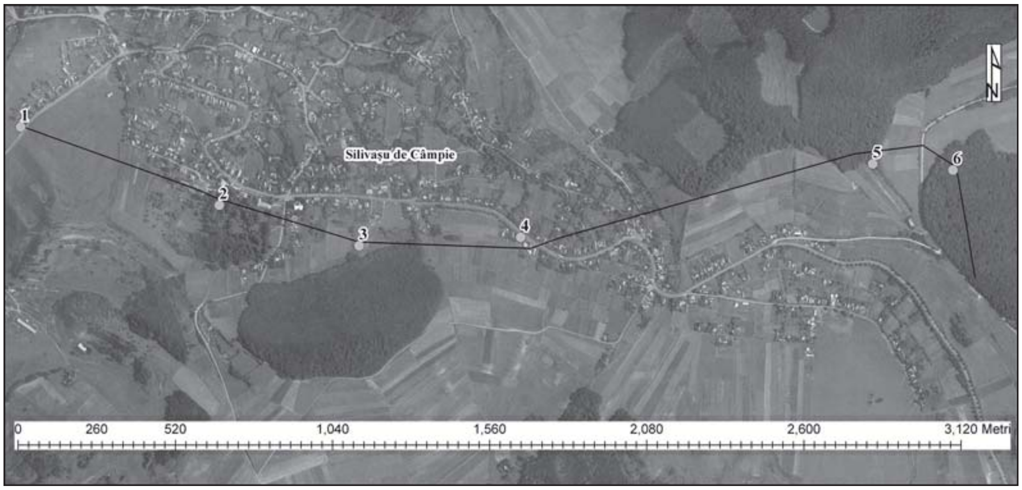

Fig. 1. ***The damage indicators map***

Fig. 2. ***The DI – Barn that has the supporting walls collapsed***

a) The first damage indicator is represented by an barn. Due to the predominance of wood as building material we considered it to be in the *Small Barns or Farm Outbuildings* category. Destruction of the supporting walls (Fig. 2), betrays the sixth degree of destruction of this damage indicator, whit wind speeds of around 97 mph or 155.2 km/h. The age and poor quality of construction has led us to choose the lower bound of wind speed for this degree of destruction, 81 mph or 130.3 km/h.

In terms of building materials this construction fits perfectly into the chosen category, however there are certain construction elements that could increase the resistance of the walls and the roof so the wind speed that can produce the same damage should be higher. This is the first problem we have encountered. Thus, all these elements that increase the resistance of a construction represented by certain elements of construction, techniques and materials used, must be identified. The same should be done for the elements that reduce the strength of a construction, such as age, improper equipment or building materials that are not of good quality. These factors should be identified for each damage indicator, because are different from one building to another.

Fig. 3. ***The second DI – A snapped chestnut tree trunk***

b) In the center of the village there is a natural reservation represented by a park. This is the next damage indicator. According to the local authorities, the park was affected at a rate of 30-40%. A chestnut tree trunk, about 20 cm in diameter, was snapped at about half of meter above the ground level (Fig. 3), indicating wind speeds up to 105 mph - 168.98 km/h. This is equivalent to the fourth degree of destruction for the *Trees: Hardwood* damage indicator. Since this tree is the only one which had this degree of destruction, and the other trees in this location are just uprooted or suffered smaller degrees of destruction, we considered the lower limit of this indicator of damage, 93 mph or 149.66 km/h.

Of all damage indicators, the categories of vegetation: *Trees: Hardwood* and *Trees: Softwood* are the damage indicators that do not need adjusting and can be used as they are, because in both countries there are the same species of deciduous and resinous, and the degree of destruction can not be differentiated (Almaşan, H. et al., 1981).

Fig. 4. ***The Third DI – Uplift of roof structure of an stable***

c) The next damage indicator is a stable. Although recently built (1996), with the resistance structure consisting of reinforced masonry walls (brick or concrete blocks), the roof structure composition (roof structure with rafters) is disregarding the standards for bearing and joining, with wood shingle roofing of average quality, it can not be classified in another category than the *Small Barns or Farm Outbuildings*. Uplift of roof structure is corresponding in the sixth degree of destruction, with estimated wind speeds up to 93 mph - 149.66 km/h.

d) The last construction affected by the tornado is a household annexes in the garden of a house, located at the 37th km of the national road DN 16 and it is in the same category as the damage indicator above, *Small Barns or Farm Outbuildings* because of the predominance of wood as building material. Lifting the roof structure or destruction of parts of the walls indicate the sixth degree of destruction, with wind speed of 93 mph - 149.66 km/h.

We treat the two damage indicators together in order to highlight another problem encountered in the evaluation. Even if they are used for the same purpose in terms of used construction materials these damage indicators are very different. The fourth damage indicator fits well into the category where it was assigned, but the third damage indicator may fall slightly in the category *One- or Two-Family Residences*. Thus, in selecting the category where to place a damage indicator we should consider first the structure type, materials and technique and the use of the building.

e) The next damage indicator is centered on an electricity pole which is made of pre -stressed concrete and was broken at about 1 m above the ground. It was considered to be in the *Electrical Transmission Lines* category. The wind speed that could cause this damage is about 138 mph, the fifth degree of destruction. We have taken into account the fact that this post was placed in the forest and the trees that fell over it could cause damage to the structural strength. Thus, a wind speed of around 125 mph - 201.16 km/h is more probable.

Fig. 5. ***The fifth DI - Broken electrical transmission lines***

Along with the vegetation category damage indicators, those of the *Electrical Transmission Lines*, *Free-Standing Towers* and *Free-Standing Light Poles, Luminary Poles, Flag Poles* do not require changes, since both structures in the United States and Romania and have the same construction materials. The problems encountered are the factors that can affect the strength of pole like structures, exemplified by this case.

f) The last damage indicator is represented by an area of 3 hectares of a beech forest, where over 90% of trees were flattened. It falls under the *Trees: Hardwood* category and in addition to trees which the vast majority fall within the fourth degree of destruction *broken trunks*, there are *trees debarked with only stubs of largest branches remaining*, falling in the highest degree of destruction, the fifth, which corresponds to wind speeds of 143 mph. Since there is only one example of this degree of destruction, we did not consider the average value for this level of destruction, but a lower value of 135 mph - 217.26 km/h.

Fig. 6. ***The last DI - Broken trunks in a deech forest***

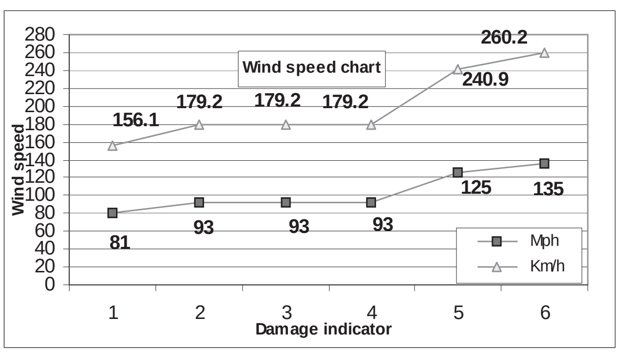

Fig. 7. ***The wind speed chart along the six damage indicators***

Fig. 7 presents the evolution chart of the wind speed in mph and km/h along the tornado path, speed determined by the degree of destruction of the damage indicators.

The EF intensity is determined individually for each damage indicator and finally the tornado is assigned the maximum value of all indicators. In this case it can be clearly seen that the wind reached speeds of 125 - 135 mph or 201.16 - 217.26 km/h at the last two damage indicators. This means that the tornado was an EF 2.

In the Silivaşu de Câmpie tornado evaluation the following issues have been identified:

- The existence of elements that reduce or increase the strength of constructions for each type of indicator of damage.

- Constructions with the same way of using are not built after the same pattern in terms of structural strength.

- Factors that may affect the structure of the resistance of poles like structures.

- Difficulties in translation of technical terms.

In this evaluation we have used only three damage indicators of the total of 28, so we conclude that possible problems may arise in the use of other indicators, problems can be identified only when these damage indicators will be used in an assessment of an tornado.

3. PROPOSED SOLUTIONS

The first step in adapting the Enhanced Fujita Scale for Romania is the translation of the document "*A Recommendation for an ENHANCED FUJITA SCALE (EF-Scale)*" proposed in 2004 by the Wind Science and Engineering Center from the Texas Tech University, which led to the implementation of the Enhanced Fujita Scale. The most important element of this translation, for each damage indicator, is the typical construction section where construction materials and techniques are described.

Also important in terms of translation and adaptation of damage indicators is a good translation of the degree of destruction. Most indicators in the same categories (buildings or vegetation) have the same degree of destruction. For example, all types of buildings have the same first level of destruction: *Threshold of visible damage*, but some indicators have specific owner, for example the first degree of destruction of the *Trees: Hardwood* is *Small limbs broken (up to 1" - 2.54 cm diameter)*.

After the translation we can determine which damage indicators are not found in Romania, or if they are found and they belong to a category by use, if they meet the criteria of the typical construction. For example, if a building that is used as an animal shelter meets the criteria of *One- or Two-Family Residences*; it won't be taken into account as a *Small Barns or Farm Outbuildings,* as the use indicates.

Elements that increase or decrease the strength of construction and factors that may affect their structural integrity must also be found for each damage indicator in hand. Knowing them is necessary in order to adjust the main wind speed between the upper and lower limits.

4. CONCLUSIONS

An adaptation of the Enhanced Fujita scale is a problem that has a solution, but it is a process that can not be rushed. We, as the authors of this article, all the members of the Association for Monitoring of Severe Weather Phenomena, will continue to analyze this problem and hope to draw into this issue as many specialists from both construction and meteorology fields as we can. Once the issue presented in this article, we will continue to carry out evaluations of tornadoes that will occur in Romania and to find solutions to problems that will arise until a final version of the Enhanced Fujita scale, adapted to the buildings in our country, will be completed.

REFERENCES

1. Almăşan, H., Apostol, A., (1981), *Pădurile României: studiu monografic*, Editura Academiei Republicii Socialiste România.
2. Buţiu C.,Nucuţă C., (2010), *Severe meteorological phenomena in Romania – The tornado from Silivaşu de Câmpie*, ERAD 2010 – European Conference on Radar in Meteorology and Hydrology - Advances in Radar Technology - Proceedings, 453 – 458.
3. *** (2004), *A Recommendation for an ENHANCED FUJITA SCALE (EF-Scale)*, Wind Science and Engenering Center, Texas Tech University
4. www.spc.noaa.gov/efscale/