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Impact Analysis of the Whirlwind Disaster on Residential Roof Frame Structures (Case Study in Tonro Kassi)

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ABSTRACT: *Damage to buildings due to wind disasters is often found on the roof truss of a building. Thus, roof truss structure is an important part of construction. This study aimed to determine the damage to the roof truss structure due to the wind disaster in Tonrokassi village, Tamalatea district, Jeneponto Regency, the vulnerability of the building and identify the existing roof truss after the disaster. The method of classifying damage levels of structures is by using the Fujita scale. Based on the field scoring results, it can be seen that the damage is almost entirely on the roof. For the level of damage for point 1, it is only damage to the roof such as zinc being released from the frame. While the house has a damage level of 2, the roof has been damaged and part of the roof frame has been blown off.*

Keywords: *wind load, tornado, roof truss, wooden structure*

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I. INTRODUCTION

A tornado is a rapidly rotating column of air that forms a connection between a cumulonimbus cloud or in rare cases from the bottom of a cumulus cloud to the ground [1]. Based on the data from the Disaster Information and Communication Data Center (Pusdatinkom), the National Disaster Management Agency (BNPB). Jeneponto Regency is listed as one of the areas with tornadoes which recur almost every year [2].

Tornadoes account for 21% of all disasters in Indonesia, and based on data analysis, wind disasters in Java are the most affected areas [3]. There have been many storms since 2018-2023, as well as in 2022. In March and October the incidence of tornadoes is relatively high. If an object is not able to withstand the wind flow, it can cause the object to be lifted or shifted, this condition causes damage, such as the roof will lift or float, the hull of the building will tilt [4] and other conditions as a result of a tornado. Evaluating data for the last 10 years, there have been 9 occurrences of tornadoes, with a total of 107 houses damaged. The latest data is that on Wednesday 9 March 2022, as many as 37 stilt and semi-permanent houses, and 1 mosque were damaged, due to being hit by a tornado in Kassi and West Kassi Villages, Tonrokassi Village, Tamalatea District, Jeneponto Regency [2].

The biggest damage caused by wind disasters is roof loss of buildings of different construction types and roof coverings. Roof framing is an important part of building construction. A roof structure is a part of a building that supports or transmits loads from the roof to the structural members of columns [5]. Especially in multi-storey buildings, although it is a testament to the development of a country, there is a greater risk due to wind [6]. Buildings in Indonesia typically use gable, hipped and side-sloping roofs (warehouses), while several types of roofs can be used for buildings, such as mansard and dome roofs. Regarding the shape of the pitched roof with some other angle variation, it was concluded that the same building height is also directly related to the wind. In other words, roofs with a large angle of inclination can be classified as high-risk buildings in the event of wind damage [7].

Structural planning of a building is intended to be a structure capable of supporting its own weight, wind forces, direct loads, and special loads acting on the building structure. Structural systems in buildings have also been developed to increase the strength and durability of building structures to withstand loads, one of which is wind loads considering Indonesia's geographical location with conditions tropical climate, with humidity higher than 75%. This condition causes instability of air masses due to the westerly and easterly winds and causes hurricanes over the continent [8]. The loads acting on the structure are calculated according to the Indonesian Load Regulations for Buildings 1983. The roof is designed from a wooden structure assembled on site or on site. In addition, it also takes into account working loads, including dead, live and wind loads [9].

This study aims to identify the damage to the roof truss structure due to the wind disaster in Tonrokassi Village, Tamalatea District, Jeneponto Regency, the vulnerability of buildings, and identify the existing roof truss after the disaster.

II. RESEARCH METHOD

Study area

Sulawesi Island is an island located in the Eastern Region of Indonesia, South Sulawesi is a province located at the southern tip of Sulawesi Island with an area of 62,482.54 km². There are 21 districts in South Sulawesi and 3 cities. The Province of South Sulawesi is directly bordered by Central Sulawesi and West Sulawesi in the north, Bone Bay and Southeast Sulawesi in the east, Makassar Strait in the west, and the Flores Sea in the south.

Jeneponto Regency is one of the regencies in South Sulawesi where Jeneponto Regency is located between 5º 23´ 12´´ - 5º 42´ 1,2´´ South Latitude, and 119º 29´ 12´´ - 5º 56´ 44,9´´ Longitude East, bordering Gowa and Takalar Regencies in the north, Bantaeng Regency in the East, Takalar Regency in the west and Flores in the south, the area of Jeneponto Regency is recorded at 749.79 km2 which includes 11 Districts [10]. One of the sub-districts where tornadoes most often occur and occurs almost every year is Tamalate District, especially in two sub-districts, namely Tonro Kassi and West Tonro Kassi Sub-Districts, Tamalatea District, these two sub-districts are the research locations whose detailed locations can be seen in Fig. 1

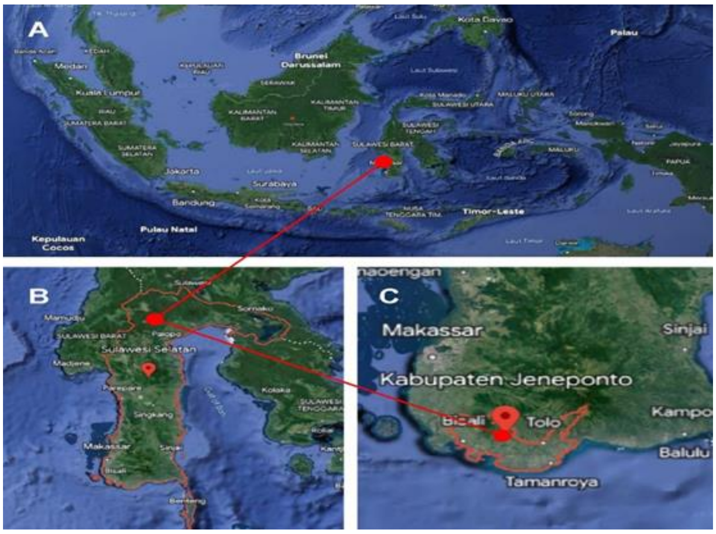

Fig. 1 Disaster-affected locations, Jeneponto Regency

Research Data

This study uses two types of data. Primary data was obtained through a field survey of the areas affected by the tornado. Meanwhile, secondary data was obtained from the Regional Disaster Management Agency (BPBD), local village heads, as well as from other supporting literature.

Data Collecting Technique

Primary data collection in this study was carried out by two methods. The first technique is saturated sampling, which is used to collect information related to the classification of vulnerabilities and damage to buildings that occur. The sample is determined based on secondary data from the local BPBD.

The second data collection stage used a purposive sampling technique. At this stage the data collected is detailed data on the existing roof truss that is damaged.

Data Analysis Technique

Data analysis in the first stage is the classification of the level of vulnerability of buildings. The second stage is the classification of the level of damage to buildings, using the Fujita scale [11].
Classification of the level of vulnerability of buildings is done by giving a score to parts of the building structure from the lowest to the highest score.

Table 1. Vulnerability scores for buildings

No	Indicator	Variable	Score
1	Roof	Zinc	1
		Asbestos	2
		Rooftile	3
		Cast	4

No	Indicator	Variable	Score
2	Middle part	Wood	1
		Unreinforced wall	2
		Reinforced wall	3
3	Base	Without base	1
		Based	2

Classification of the level of damage to buildings is done by way of assessment using the *Fujita* scale.

Table 2. *Fujita* scale score

Category	Damage level	Score
F0 (Weak)	Damage to the roof of the house	1
F1 (Medium)	The roof of the house is raised	2
F2 (Strong)	The roof of the house lifted with all the piles	3
F3 (Very strong)	The roof and walls of the house were crushed, broken and detached from their basic framework	4
F4 (Severe)	Flat concrete houses, buildings with less strong foundations were thrown away	5
F5 (Extraordinary)	Even the strongest foundations are lifted and shifted	6

Source: [11]

III. RESULTS AND DISCUSSION

Building Vulnerability

Three parts of the building are reviewed to determine the level of vulnerability of the building, namely the roof, the middle part, and the foundation. Based on the score variable in Table 1, the building structures at the study sites can be classified as follows.

Table 3. Building Structure Score

No	Structure	Score	Sub-district	
			Tonro kassi	Tonro Kassi Barat
1	Roof	1	22	14
2		2	-	-
3		3	-	-
4		4	1	-
5	Middle part	1	22	14
6		2	-	-
7		3	1	-
8	Base	1	-	-
9		2	23	14

In the affected areas, there are 2 types of roofs, namely roof tiles and zinc. At the time of the survey, the roof covering of this type of tile only experienced a slight shift, it did not come off and was thrown far from its original position. This shows that the zinc roof covering has a higher vulnerability than buildings with tiled roof coverings.

Builiding damage

This tornado disaster caused 37 houses to be damaged, this number was spread over two sub-districts. This data is also in line with the secondary data obtained from the Jeneponto Regional BNPB. The following is data on building damage that occurred at the disaster site.

Table 4. Building damage

No	Sub-district	Score	Number
1	Tonro Kassi	1	17
2		2	6
3	Tonro Kassi Barat	1	10
4		2	4

Based on the results of the scoring in the field, it can be seen that the damage occurred almost entirely in the roof. As for the level of damage with a score of 1, there is damage to the roof covering only such as zinc being detached from the frame. While the house with a damage level score of 2, experienced damage to the roof covering and part of the roof frame was detached.

The roof damage that occurs is due to the nature of the wind which sucks and sometimes grabs objects in front of it, so that the most dominant part of the roof is damaged as shown in Figure 2.

Fig 2. Sample of roof damage

The link between building vulnerability and wind speed is that high building vulnerability and high wind speed can also affect high damage potential when compared to other building vulnerability classes. Conversely, if the low vulnerability of a building is passed by high wind speeds, then it is likely that the building has the potential to experience low damage.

Post-Disaster Existing Roof Forms

The distinctive feature of the stilt house structure is the division of a stilt house component into the smallest parts which are then put together to become a building. Broadly speaking, each part of the stilt house structure consists of: roof, columns and walls, floor plates, and foundations [12].

The gable roof structure uses trusses as roof supports which are then channeled to column points which must be balanced with accurate planning and calculations [13]. If it looks from the outside, the roof model can be displayed in Figure 3.

Fig 3. Outer roof view

Fig 4. Roof truss seen from inside the house

The existing roof truss uses a conventional truss structure as shown in Figure 4 with beams measuring 4 x 11 cm. The span of the trusses is 6 m with a maximum distance between the trusses of 3 m. The curtain rod is 6x6cm and the curtain rod is 3x4cm. While the roof covering is zinc material.

Meanwhile, for earthquake-resistant timber frame house design, the joints must be fixed with nails at least 2.5 times the thickness of the smallest wood, with at least 4 (four) pieces. If the wooden structure is subjected to high stress, wooden joints should be secured with dowels of at least 10 mm [14].

IV. CONCLUSION

Based on the vulnerability of buildings to structural damage occurring in the study area, structural damage mainly occurs on the roof of the building. There are also buildings that have damaged the central part of the structure. This factor is due to the structural damage of the middle part of the building, in the form of wood and plywood, so the material is not sufficiently resistant to wind, thus vulnerable to buildings of medium height and big. liable to suffer the same damage.

REFRENCES

[1]. Maromon, R.Y.Y., Ngurah, I.G. Hardy, W., & T.M.C. (2019). Kajian Rumah Ramah Angin di Kota Kupang, Nusa Tenggara Timur, Gewag, 1(1), 14-19.

[2]. Badan Nasional Penanggulangan Bencana (BNPB). 2022. Pusat Data Informasi dan Komunikasi Kebencanaan (Pusdatinkom). https://di bi.bnpb.go.id..

[3]. Badan Nasional Penanggulangan Bencana (BNPB). 2023. IRBI Indeks Risiko Bencana Indiensia. 1(1).

[4]. Amri SB, Syukur LOA. (2017). Analisis Aliran Angin Pada Atap Miring Melalui Uji Simulasi Flow Design. Langkau Betang J Arsit. 4:136-143. https://doi.org/10.26418/LANTANG.V4I2.23252.

[5].] Syamsudin, S. F., Susanti, E., & Istiono, D. H. (2018). Analisis Komparasi Perencanaan Struktur Rangka Atap Baja Ringan Untuk Rumah Tipe 180 Dengan Tipe Kuda-Kuda Yang Berbeda. Prosiding Seminar Nasional Sains Dan Teknologi Terapan, 0(0), 383. https://ejurnal.itats.ac.id/sntekpan/article/view/379

[6]. Schueller W.(1977). High-rise building structures. 274.

[7]. San B, Xu C, Qiu Y. (2019). Three-Dimensional Aerodynamic Optimization of Single-Layer Reticulated Cylindrical Roofs Subjected to Mean Wind Loads. Advances in Civil Engineering. Vol. 2019.

[8]. Darman R. Analisis Data Kejadian Bencana Angin Puting Beliung dengan Metode Online Analytical Processing (Olap). Sintech (Science Inf Technol J 2019;2:18–23. https://doi.org/10. 31598/SINTECHJOURNAL.V2I1.298.

[9]. Hakiki, M. S., & Hamzah, H. (2017). Analisa Pembangunan Rumah Tinggal Sederhana Dari Segi Perencanaan Atap. Jurnal Keilmuan Dan Terapan Teknik, 06(2), 61–65..

[10]. BPS, 2022. Jeneponto Regency in Figures. BPS-Statistics of Jeneponto Regency. 2022.

[11]. Putra, K. P. B. (2015). Analisis Kerentanan Bangunan terhadap Bencana Angin Puting Beliung di Kecamatan Tanon Kabupaten Sragen. In Publikasi Ilmiah.

[12]. Gardjedi, H., Fajrin, J., & Sugiartha, I. W. (2016). Alternatif Rancangan Bangun Rumah Masal Berbasis Kontruksi Pangung Pada Lahan Berkontur. July, 1–23..

[13]. Sudarmadji. (2014). Berpenutup Genteng Untuk Rumah Tinggal. PILAR Jurnal Teknik Sipil, 10(1), 45–54. https://jurnal.polsri.ac.id/index.php/pilar/article/view/424.

[14]. Kamurahan Richard, S. (2018). Struktur Dan Konstruksi Rumah Panggung Masyarakat Kampung Jawa Tondano (Jaton) Ditinjau Dari Prinsip-Prinsip Bangunan Tahan Gempa. Media Matrasain, 15(1), 1–8.