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CYCLONE RESISTANT LOW COST HOUSING IN COASTAL AREA OF BANGLADESH

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Abstract: The coastal zone of Bangladesh has been facing wind related natural disasters like sidr, tornado, cyclone etc every year. These disasters cause large scale damages to socioeconomic condition, destructions of infrastructures-residents and death, injuries to human and animals. The main reason is non-engineered houses constructed by the local people due to lack of technical guidance and affordability. Considering the growth of non engineered housing, and the damage level of housing due to past wind induced disasters, it became essential to develop an appropriate wind resistant housing model for safe shelter and minimizing the losses of lives and economy. The aim of this study is to investigate the present housing condition in southern part of Bangladesh to develop and establish a comprehensive, safe and economical design concept, so that people under poverty can build structurally robust house to resist high speed wind within their affordable limit. In preliminary of dissertation, present housing patterns and extreme wind speed faced in southern part of the country are surveyed. The models of existing houses are made (reduce scale) using survey data for laboratory test to investigate ultimate wind load capacity and failure mode of existing house. The same model is then strengthened by bracing in the roof truss and cross bracing in the wood wall. Both experimental study using UTM and numerical study by computer program SAP2000 has performed for existing and proposed housing model basis on the concept of suction force acting on roof during wind action. It was found most of them are failed by joint failure and wind resistance of such existing houses increase about 40%-50 % when tie and bracing strengthening technique is applied.

Keywords: Non-engineered house, Economical house, Wind load, Coastal Zone, wind induced damage, Strengthening, Tie and Bracing.

INTRODUCTION

Bangladesh is a low land deltaic country having 33% people lives on coastal zone of Bay of Bangle covering 19 districts. Because of illiteracy and lacking of idea of modern house, these

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coastal people built their house by assistance of locally available woodcraft, artesian using wood, bamboo, tin and thatches for living somewhat only. Hence they have to lose their house every year due to natural disaster especially cyclone, wind storm, sidr, nargis etc. In 1991 they faced deadliest cyclone of wind speed 250km/hr. which causes 138,000 people dead and 10 million people homeless, loss of billion of money and severe sufferings. Unfortunately it's true that Bangladesh National Building Code-93 (BNBC-93) doesn't provide any provision for wind resistant design for above mentioned non-engineering housing. Hence the phenomenon of losing house in disaster is going on. To minimize the loss of houses and economy in coastal zone of Bangladesh under high wind speed like cyclone it became urgent and essential to establish rules and guidelines for construction of non-engineering rural house in Bangladesh National Building Code (BNBC). The aim of this study is to investigate the present housing condition in southern part of Bangladesh to develop and establish a comprehensive, safe and economical design concept, so that people under poverty can build structurally robust house to resist high speed wind within their affordable limit.

LITERATURE REVIEW: In earlier Rumana Rashid [1], made a detailed survey on types of houses, according to materials and location. He shows the advantages using tie and cross bracing for bamboo frame structures. But there is no technical and experimental validation of his suggestion. Ankush Agarwal [2] provides explanation on how wind damage building, catastrophic & components failure and effect of cyclone. His architectural solution for cyclone resistant rural house is remarkable and leads to structural and experimental investigation. Bhandari and Krishna [3], recommended protecting house by hillock, group planning of house, use of roof truss, rafter bracing, eaves bracing and vertical bracing. Their proposals are consider for the current paper theme. Jonathan Ochshorn [4] recommends using of collar beam along the ridge tie to prevent rafter separation. Although it prevent the separation of ridge but it couldn't prevent the uplift of roof. So it's recommends for engineering analysis for use of collar beam. Ansary and Seraj's [5] experimental study represents the effect of roof slopes and openings of wall on internal and external wind pressure exerted in house. It found that roof slope ranging 30^0 to 40^0 is suitable against strong wind and also suggests using bracing or tying. Choudhury [6] has strongly emphasized the need of technical knowledge and training to local artisan for structurally strong and economical house. His technical suggestions regarding how to make house safe and how the existing houses can be restrenghtened are remarkable. In earlier investigation Alam [7] strongly recommended the use of tie bracing to make structurally strong rural house. He modeled existing house using inverted v shape tie along side wall and found deflection is reduced by 95% as a result of strengthening. It needs the experimental validation of his theoretical result.The training program by Mallick [8] has leaded a vital role for design and implementation of coastal cyclone resistance house by using horizontal and vertical cross bracing, metal straps and nylon ropes for firmly fixed with wall structures. But there is no any scientific background. So further intensive research to establish their recommendation.

NUMERICAL ANALYSIS

A numerical study of existing housing model and restrengthening model are done by SAP2000. In this analysis a house having plan 24 *18 feet are considered from previous investigation [7]. The house has elevation of roof level at 12 feet and total height of at roof tip is 18'. The inclination of roof is assumed to 33.69^0 as per reference [5]. All members for the house are considered as wooden and the roof is GI sheet. The columns are 6*6 inch, Chord 6*4 inch, Truss member 3*3 inch, GI sheet 1mm is considered. The Young Modulus of Elasticity is 1100 &10000 kip/in^2 and density $14.47*10^{-6}$ & $98*10^{-6}$ for wood and steel respectively. The conventional structure as shown in Fig. (1a) is strengthening using tie and bracing in Fig. (1b). The vertical tie bracing are provided along parallel to wind direction which greatly reduce the lateral deflection of the house as show in Fig. 2. At the bottom chord level cross bracings are provided which increase the rotational rigidity of the house. To apply the wind force as wind velocity tin of negligible thickness are considered.

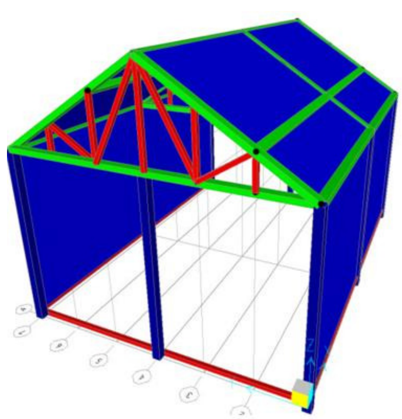

Fig 1a) House without Bracing

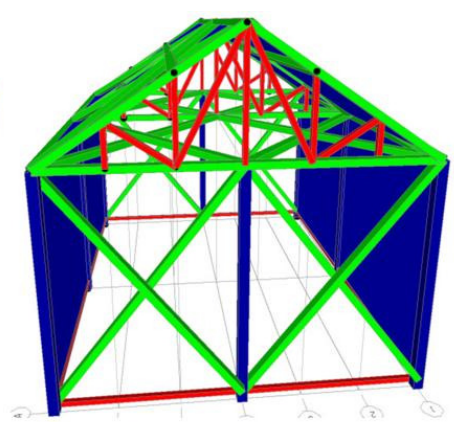

Fig 1b) House with Bracing

The wind pressure coefficient on wall is 0.80 & 0.572 and on roof is -0.0155 & -0.70 along windward and lee ward direction respectively is calculated according to BNBC-93 with maximum wind speed 260km/hr The numerical study conducted on unbrace model by SAP2000 found that average deflection is 46mm. But after application of bracing the deflection reduces to 0.5mm which is about 100% reduction of deflection. The comparison of deflection of house with and without bracing is shown in Fig. 2.

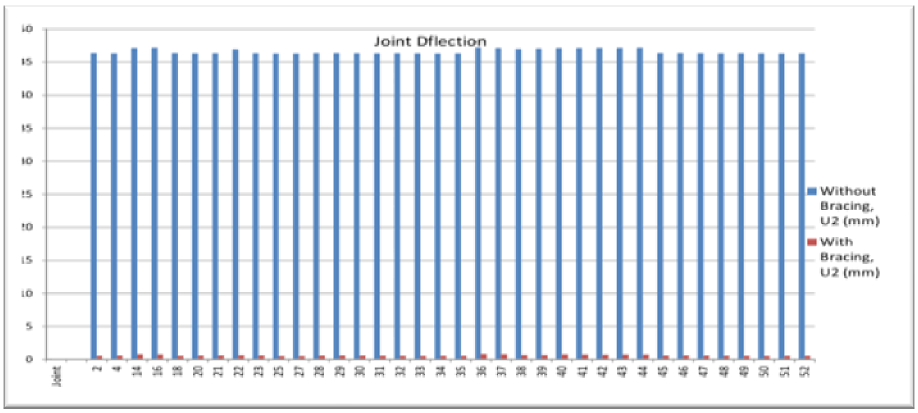

Fig 2: Deflection comparison of house with and without bracing along wind direction only

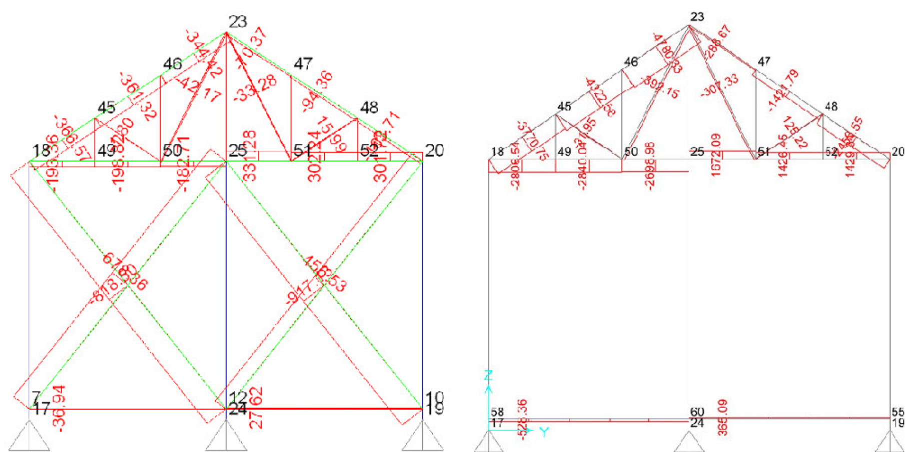

Fig 3a: House with bracing (Axial forces) **Fig 3b:** House without bracing (Axial forces)

The analysis result shows that the member forces also reduce due to application of tie and bracing. This reduction in forces is due to re-adjustment after application of bracing. As a result the possibility of joint failure that was occurs in unbraced house greatly reduce due to application of tie and bracing. The Fig. 3, 4, 5 and Table 1, 2 shows the comparison of member force due to application of tie and bracing with existing house.

Member	Without Bracing	With Bracing	Member	Without Bracing	With Bracing	Member	Without Bracing	With Bracing
18-45	-3770.7	-366.5	47-4	-1421.7	-94.3	51-25	1672.1	331.28
45-46	-4322.5	-361.3	48-2	-2458.5	108.3	25-50	-2698.9	-182.28
46-23	-4780.3	-344.4	20-5	1429.3	301.7	50-49	-2840.0	-198.82
23-47	-288.6	-70.3	52-5	1426.4	302.2	49-18	-2806.5	193.36

Table 1: Axial forces (N) comparisons in truss member

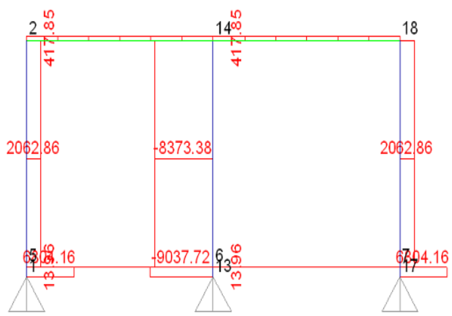

Fig 4a: Axial forces in windward side wall with bracing

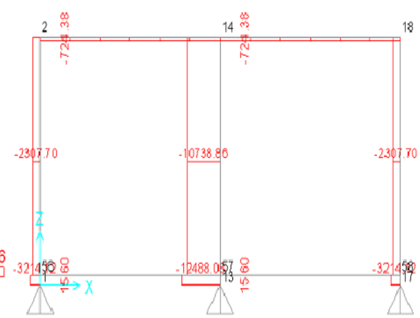

Fig 4b: Axial forces in windward side wall without bracing

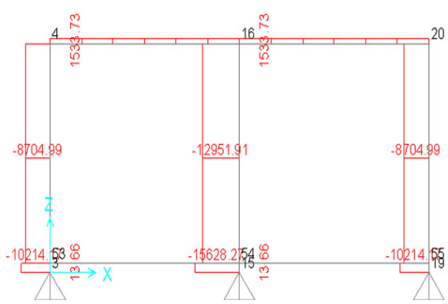

Fig 5a: Axial forces in leeward side wall without bracing

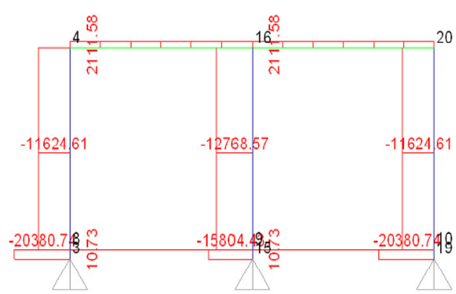

Fig 5b: Axial forces in leeward side wall with bracing

Member	Without Bracing	With Bracing	Member	Without Bracing	With Bracing
Windward Direction			Leeward Direction		
5-2	-2307.70	2062.86	63-4	-8704.99	-11624.61
2-14	-724.38	417.85	4-16	1533.73	2111.58
14-18	-724.38	417.85	16-20	1533.73	2111.58
18-7	-2307.70	2062.86	20-55	-8704.99	-11624.61
14-6	-10738.80	-8373.38	16-54	-12951.91	-12768.57

Table 2: Axial forces (N) comparisons for side wall

The analysis result shows that there is a little variation of support reaction. The uplift and downward force acting on the support is as follows:

Support Number	Without Bracing	With Bracing	Support Number	Without Bracing	With Bracing
1	3214.12	-6784.75	19	10214.17	20360.87
3	10214.17	20360.87	24	4079.47	5568.97
13	12488.08	9039.45	26	4019.47	5568.97
15	15628.27	15802.25	Total	63131.87	63131.87
17	3214.12	-6784.75			

Table 3: Support resection (N) comparisons only vertical

It’s found that application of tie and bracing increase the stability of house against overturning or uplift under strong wind. Although it causes increase of uplift force in support 3, 19, 24 and 26. To increase the stability of house against uplift square concrete block attached with bottom of column by steel cable may be used. Again, it is found that due to application of tie and bracing the tensile force in most of the truss member reduce greatly. The reduction of member force causes stability of against joint failure.

EXPERIMENTAL ANALYSIS

For experimental analysis the two wooden structural models are built as shown in figure 6. The joint of wooden frame on roof are pin connected and then tie with steel rope. The truss member connects with vertical column using small steel plate and pin. The experimental analysis is done by Universal testing machine. As there is no facility to provide any lateral force on the model, it is assumed that the structure is subjected to equal suction force on roof only. The force is applied by steel cable supported from high stiff steel plate so that each cable provides uniform suction force to the model. The experimental model and experimental setup are as follows:

Fig 6: Experimental setup under suction force in UTM

From experimental analysis of the model, it found that the model without bracing can sustain only 3kN load on the other hand the model with bracing can sustain about 4.5 kN as shown in Table 4. So the load carrying capacity increases up to 50 % due to application of bracing system. In both case the model is failed by joint failure since only vertical suction force has applied.

Types of Model	Load carried	Remarks
Without Bracing	3000 N	Capacity increased by 50%
With Bracing	4500 N	

Table 4: Experimental result comparisons

CONCLUSION AND RECOMMENDATION

From the numerical and experimental study presented in this paper, it’s found that application of tie and bracing increase the load carrying capacity of the traditional houses. As the member force in roof truss are greatly reduce as an application of tie & bracing, it reduce the possibility of joint failure and blowing up of roof. The downward force on column indicate it stability against blowup. Again it's found that the deflection of the house reduce greatly about 99.5% as application of tie and bracing. So it can be concluded that the use of tie and bracing can be applied for construction of non-engineering house in coastal zone of Bangladesh.

REFFERENCES

1. Rumana Rashid: Traditional Houese of Bangaldesh: Typology of houses according to materials and location.
2. Ankush Agarwal, GoI-UNDP, Diasater Risk management Program, March 2007: Cyclone Resistant Building Architecture.
3. Dr. N. M. Bhandari, Dr. Prem Krishna, Dr. Krishen Kumar: Wind Storms, Damage and Guidelines for Mitigative Measures.
4. Jonathan Ochshorn: Guidelines for use of Collar Beams.
5. U K Roy, M A Ansary, S M Seraj, R L P Hodgson: An Experimental Study Towards Development of Wind Resistant Rural Homes in Bangladesh.
6. J.R. Choudhury, Design and Construction of Houses to Resist Natural Hazards, First Keynote Address, Implementing Hazard Resistant Housing, The Proceeding of H&H DHAKA96 workshop held at BUET, Dhaka, December 1996, pp. 10-17.
7. M. R. Alam, M. T. Rana and S. K. Dev: An experimental study of wind-resistant low cost housing and some construction guidelines for coastal houses.
8. Fuad H. Mallick, Khondaker Hasibul Kabir, Aminur Rahman: Sructural Strengthening of houses and infrastructure in Bangladesh.
9. Bangladesh National Building Code BNBC-93.