HYBRID WOOD-MASONRY WALL TEST AND VERIFICATION OF TWO-DIMENSIONAL MODELLING APPROACH

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ABSTRACT

Two-storey hybrid wood-masonry wall systems were tested under reversed cyclic loads. The test data were obtained to verify a two-dimensional (2-d) numerical modelling approach which would be used to predict the seismic performance of hybrid building system. The test results show that the connections failed first when the load was applied on the wood frame, while masonry core failed first when the load was applied on masonry core. The developed 2-d finite element system model could reasonably predict the performance of hybrid building if reliable input properties of system elements are available.

INTRODUCTION

Elevator shaft and stairwell core in multi-storey light wood frame buildings are usually constructed with non-combustible materials like reinforced concrete or masonry. As the storey limit of light wood frame buildings has been increased from 4 to 6 in the Province of British Columbia since 2009, it is beneficial to take advantage of the stiffer core to reduce building deflection under lateral loads. Research work on the performance of this type of hybrid building system is limited.

OBJECTIVE

The purpose of these tests was to simulate the seismic performance of hybrid building system to get a good understanding on how lateral loads are transferred between wood sub-system and masonry sub-system through the connection.

METHDOLOGY

EXPERIMETAL PROGRAM

Two two-storey hybrid wood-masonry walls with load applied at the second storey of wood wall (hybrid wall HW1) and masonry wall (hybrid wall HW2), as well as its components were tested in this project. Fig. 1 shows the details of the walls and connection configurations. Fig. 2 shows the test set-up of the walls and connections.

VERIFICATION OF 2-D NUMERICAL MODEL

Fig. 3 shows the schematic of 2-d modeling approach. This 2-d model was implemented using the commercial software ABAQUS V6.10 together with a user-developed subroutine that incorporates the Bouc-Wen-Barber-Wen (BWBN) hysteresis model [2]. Fig. 4 shows the comparison of hysteresis loop of scaled test data and the numerical model. The 13 parameters of each BWBN model are calibrated with ±10% difference of dissipated energy.

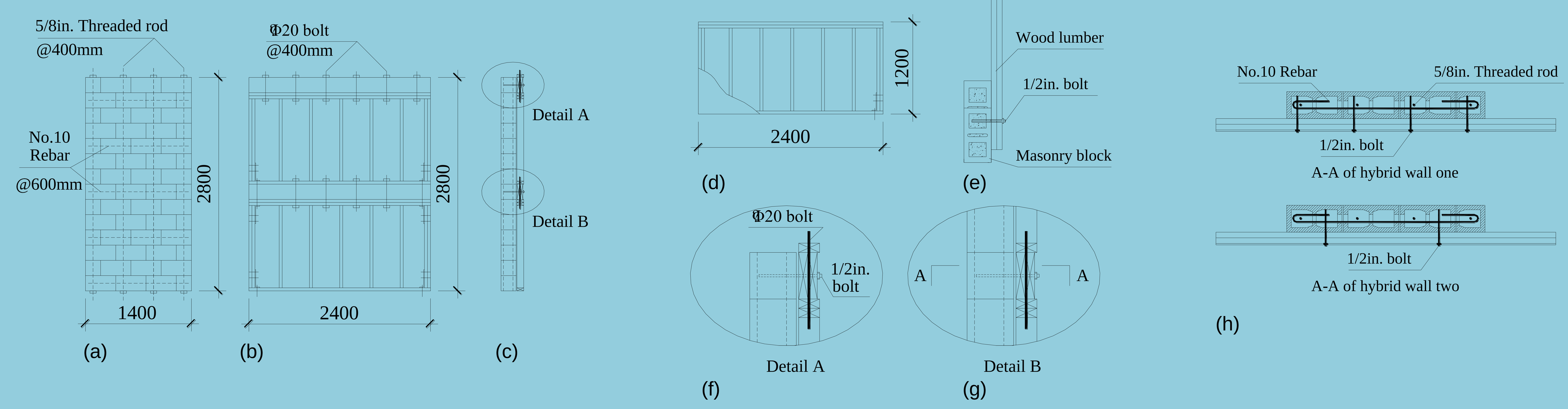


Figure 1: Wall configurations: (a) masonry sub-system of hybrid wall; (b) wood sub-system of hybrid wall; (c) side view of hybrid wall; (d) one-storey wood wall; (e) wood-masonry connection; (f) Detail A; (g) Detail B; (h) cross section of hybrid walls

(a) (b) (c) (d) (e)

Figure 2: Test set up: (a) hybrid wall one; (b) hybrid wall two; (c) two-storey masonry wall; (d) one-storey wood wall; (e) wood-masonry connection

Table 1: Loading protocols

Step	Cycles	Amplitude(mm) Protocol 1	Protocol 2
1	3	6	3
2	3	12	6
3	3	18	9
4	3	24	12
5	3	36	18
6	3	48	24
7	3	60	30
8	3	72	36
9	3	84	42

Note: Protocol 1 was used for hybrid walls and two-storey masonry wall; Protocol 2 was used for wood-masonry connection and one-storey wood wall

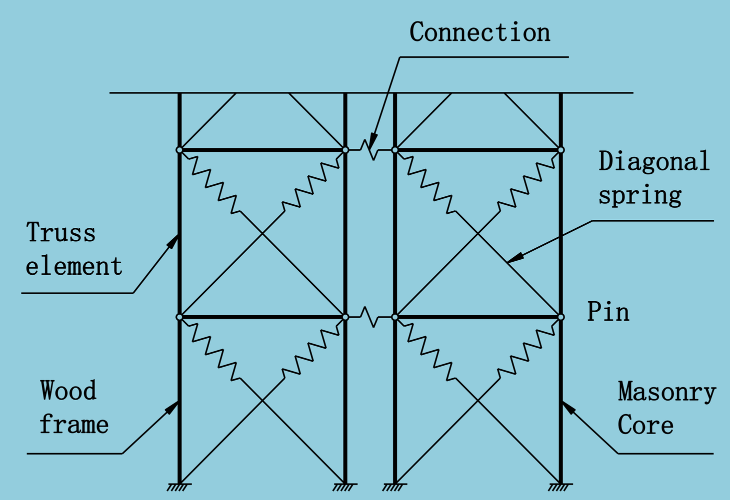
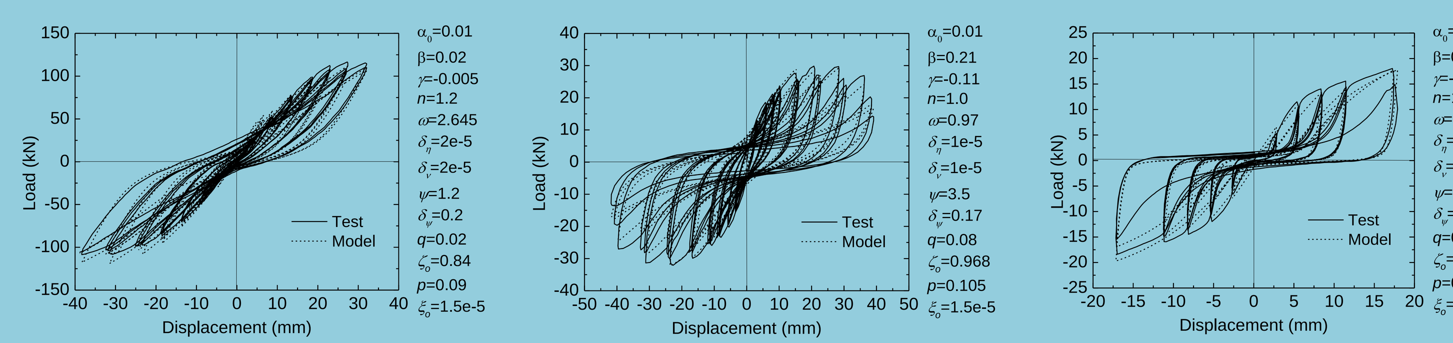


Figure 3: Schematic of 2-d modelling approach

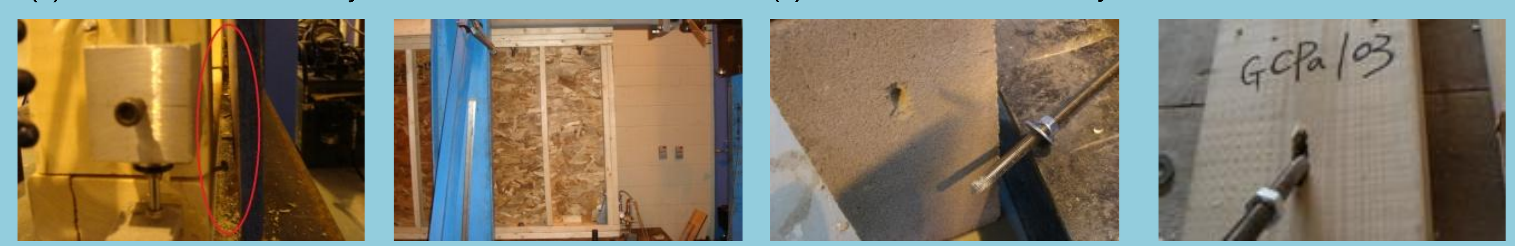


(a) (b) (c)

Figure 4: Comparison of hysteresis loops of test and modelling analysis : (a) 1.4m × 1.4m masonry wall; (b) 2.4m × 1.4m wood wall; (c) Wood-masonry connection

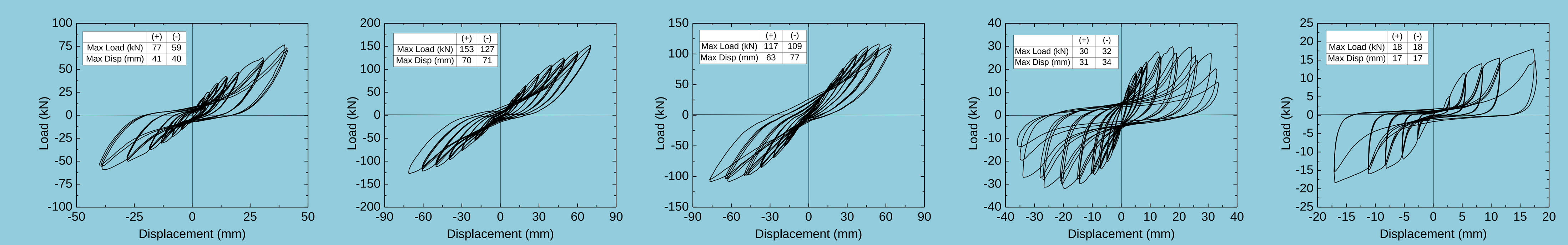
RESULTS

(a) Local crack of masonry block and bolt broken (b) Shear crack of masonry wall and threaded rod broken (c) Shear crack of masonry wall and threaded rod broken



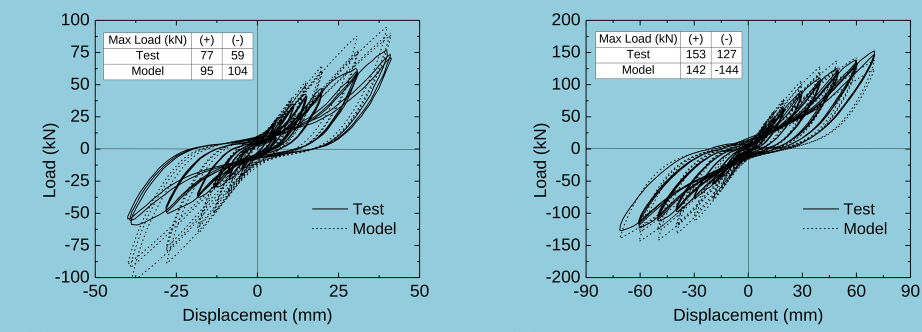
(d) Sheathing nails broken (e) Local crack of masonry block and bolt broken

Figure 5: Failure mode of test specimen: (a) HW1; (b) HW2; (c) two-storey masonry wall; (d) one-storey wood wall; (e) wood-masonry connection



(a) (b) (c) (d) (e)

Figure 6: Hysteresis loops of test specimen : (a) HW1; (b) HW2; (c) two-storey masonry wall; (d) one-storey wood wall; (e) wood-masonry connection



(a) (b)

Figure 7: Comparison of hysteresis loops of test and model: (a) HW1; (b) HW2

EXPERIMETAL PROGRAM

Fig. 4 and Fig. 5 show the failure mode and hysteresis loops of test specimen respectively. In these laboratory tests, the wood shear wall and wood-masonry connection show nonlinear, inelastic performance under reversed cyclic load and have stiffness degradation and pinching phenomenon to different degrees. For masonry wall, there is no clear strength degradation and the failure is brittle.

VERIFICATION OF 2-D NUMERICAL MODEL

Fig. 6 shows the comparison of hysteresis loops of test and model. The large discrepancy between the model prediction and the test results in HW1 may be due to the variations in wood-masonry connection performance and the differences in the modeling and the test assemblies.

CONCLUSIONS

A hybrid wood-masonry wall system as well as its elements were tested under reversed cyclic load in the laboratory. The tests provided a good indication on how the load transferred between wood and masonry sub-systems when they were structurally connected. Meanwhile, a 2-d numerical modeling approach was verified on the pseudo-static level using the test data in this project. The results showed that the developed 2-d finite element system model could reasonably predict the performance of hybrid building if reliable input properties of system elements are available.

ACKNOWLEDGEMENTS

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