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TITLE OF THE PAPER: EXPERIMENTAL CONFIRMATION OF A COMPUTER MODEL OF RACKING BRACING FOR A STEEL-FRAMED BUILDING

AUTHORS: Frederick A. Thulin, Jr. and William J. Green

ORGANIZATION/ENTERPRISE: USG CORPORATION
Graham J. Morgan Research Center
Libertyville, IL 60048 USA

KEYWORDS: Computer Program, Racking Bracing, Light Steel-Framed Buildings

SUMMARY

USG Corporation, Research Department, has developed a computer program, DSCSRACK, for designing racking bracing in cold-formed steel-framed buildings.

The program uses as input the building geometry, wind loading condition, and member specifications. From these data, using finite element analysis, the loads and stresses on the braced panel components are calculated. The bracing is then sized and the fastening specified.

To verify the computer program, a full-scale load test simulating wind conditions was conducted on a 1-1/2 story cold-formed steel-framed building, 3.66 meters by 7.32 meters in plan, having screw-attached, gypsum sheathing.

The computer program modeled the behavior of the building within 10%. These test results verified experimentally that the computer program is adequate for analyzing and designing racking bracing and connections in cold-formed steel-framed buildings.

TITRE DU TEXT: CONFIRMATION EXPERIMENTALLE D'UN MODELE D'ORDINATEUR DE CONTREVENTEMENT D'UN OUVRAGE EN CADRE D'ACIER DE BATIMENT

AUTEURS: Frederick A. Thulin, Jr. et William J. Green

ORGANIZATION/ENTERPRISE: USG CORPORATION
Graham J. Morgan Research Center
Libertyville, IL 60048 USA

MOTS-CLES Programme d'Ordinateur, Contreventement, en cadre d'acier léger Bâtement

SOMMAIRE

Le centre des recherches techniques de USG Corporation a developé un programme d'ordinateur, DSCSRACK, pour a projeter un système de contreventement pour un ouverage en cadre d'acier.

Le programme considère l'aspet geometrique du bâtiment, la poussée du vent et les membres specifiés. Avec cette information, le chargement et la tension de chacque tirant peut être analysés en employant la méthode des élements finis. Alors, le largeur de contreventement et sa méthode de visser sont specifé.

Pour verifier le programme d'ordinateur un essai de charge simulant la pousée du vent etait appliqué sur un modèle construit d'ossature d'acier. Le modèle etait composé d'un étage et demi en pleine échelle. Les membres etaient froid-formée des plaque d'acier. Le bâtiment d'essai avait 3.66 metres de largeur par 7.31 metres de longuer. Des planches de gypse type extérieur, étaient vissée á l'ossature sur un seul coté.

Le programme d'ordinateur à modélé le comportement du bâtiment dans l'eviron de 10%. Les resultats des essais ont verifié experimentalement que ce programme d'ordinateur est suffisant pour analyser et projeter les largeurs de contreventement et le système de visser pour les bâtiments froid-formès en cadre d'acier.

EXPERIMENTAL CONFIRMATION OF A COMPUTER MODEL OF RACKING BRACING FOR A STEEL FRAMED BUILDING

by

Frederick A. Thulin, Jr. and William J. Green

PROBLEM

The accurate and rapid design of racking bracing, particularly for 3- and 4- story cold-formed steel-framed buildings, is a necessary component of the structural calculations. Computer program SAP IV, which is in the public domain, used with the new pre-processer and post-processer program to simplify the input/output data is suited for the design and analysis of racking bracing. USG Corporation Research Department has developed a computer program DSCSRAK, incorporating this idea for designing racking bracing in cold-formed steel-framed buildings. Experimental verification is needed to determine whether the computer program calculated the racking bracing correctly.

OBJECTIVE

The purpose of this investigation is to verify experimentally the adequacy of the computer program DSCSRAK by observing the behavior of full-scale buildings subject to similar wind loads and to compare the results with those predicted by the computer program. Computer program DSCSRAK uses as input the building geometry, wind loading condition, and the member specifications. From these data, using finite element analysis similar to SAP IV, loads and stresses on the panel components are calculated. Also, the maximum displacements are determined. The bracing is then sized and the fastening specified.

LOAD TESTS

Thirteen small-scale tests and one full-scale test were conducted.

Small-scale tests were performed to determine the adequacy of the various racking bracing detail configurations. Tests revealed that a single strap had an ultimate capacity of 3.11 kilonewtons, and a double strap 62.83 kilonewtons.

The full-scale test was performed on a 1-1/2 story cold-formed steel-framed building 3.36 meters by 7.31 meters in plan, having screw-attached, gypsum sheathing. It was erected in the Graham J. Morgan Research Center Systems Laboratory on the universal test frame.

Horizontal and vertical loads were applied to the building simultaneously to simulate the wind loading distributions specified by the 1982 Uniform Building Code. Strains, loads and displacements were measured utilizing strain gauges and transducers. These were recorded with a Hewlett-Packard Datalogger. Loads were applied in several increments ranging from 120 to 3 830 pascals, simulating wind pressures in three separate cycles.

During the third load cycle, the final load increment was increased to loads equivalent to about 7 326 pascals wind pressure. At that load, the maximum horizontal deformation was 32.7 mm. The maximum horizontal racking bracing strap load was 28 939 kilonewtons (on two straps) which is a stress of 156 000 kilonewtons. At this load increment the sheathing began to crack at window openings, and the test was terminated. There was essentially no permanent set; thus, the building was still elastic. Figures 1-4 show the test set-up and the failure mode.

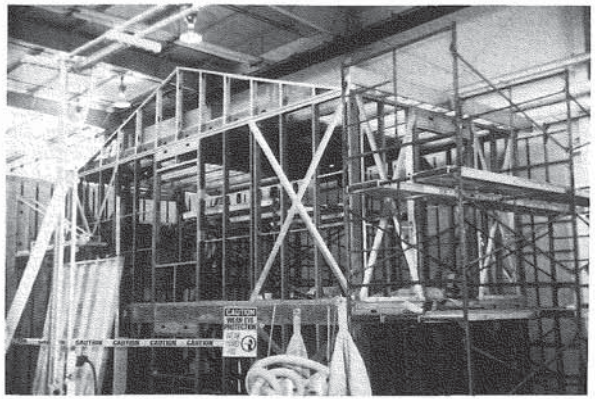


Fig. 1 - Gable framing and first story X-bracing

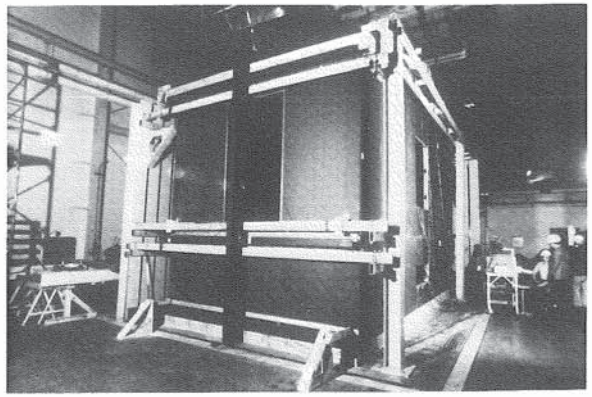
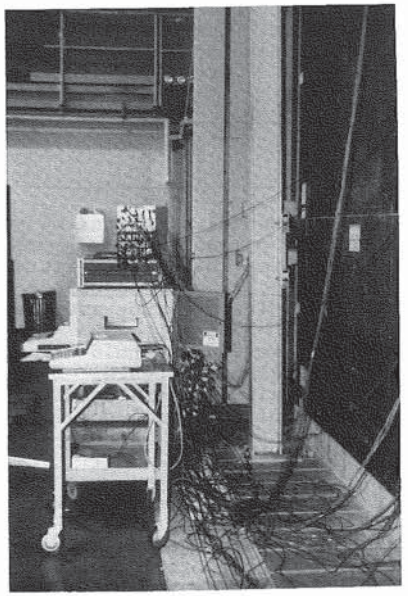


Fig. 2 - Building instrumented and ready for test.

Fig. 3 - Recording Instrument Station



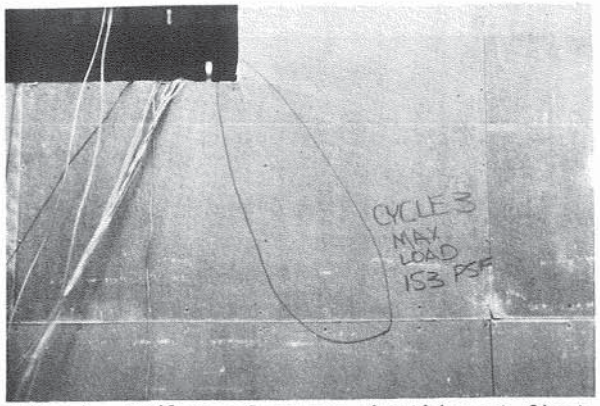


Fig. 4 - Failure of gypsum sheathing at first story window opening at sill-jamb juncture. (Crack typical at several locations.)

EVALUATION OF DATA

Data for each load increment were processed on the DSCSRAK computer program. Computed strap loads and deformations were compared with measured values on the full-scale test as follows:

TABLE 1

Item	Average ratio: Test value: Computer value	Standard Deviation
Maximum horizontal displacement	1.12	0.24
Basement strap loads	1.01	0.13
1st Story strap loads: as measured	0.62	0.08
adjusted*	0.94	0.12

* Horizontal loads at top averaged 67% of UBC-82 loads

Behavior of screws and hold-down bolts were compared with data from the small-scale tests. The computer indicated that more screws and hold-down bolts were needed for the same load than the results of the small-scale tests showed.

CONCLUSION

The computer program modeled the behavior of the building within 10% for load criteria, and 12% for displacement criteria. Thus, the test results verified experimentally that the DSCSRACK computer program is adequate for analyzing and designing racking bracing and connections in light steel-framed buildings.

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