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Optimum connection of LSF system braces using the seismic-ANN approach

Hossein Mirzaaghabeik*, Hamid Reza Vosoughifar

Department of Civil Engineering, South Tehran Branch, Islamic Azad University, Tehran, Iran

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ABSTRACT

Lightweight steel framing (LSF) has been proposed as an economic and earthquake-resistant system. The tendency of mass constructors to use this system is due to it being a full industrial process. One of the systems that resist lateral load in cold-formed steel structures is the application of braces. Optimization and improvement of connections for these braces have been considered by experts in this field of research. In this paper, experimental studies and normalization and simulation by artificial neural network (ANN) were used. The results of the research have been applied to create a nonlinear relationship. All input and target data must be normalized and then simulation and training by a neural network can be performed. In this research, two layers have been used. One of these is a sigmoid layer. The results show that optimal connections in light weight steel framing systems have suitable plasticity, load capacity and nonlinear relations. Statistical analysis with SPSS software shows that there is no significant difference between the neural network and experimental results (P-Value > 0.05).

1. Introduction

Lightweight steel framing using thin-walled steel members was first used as a non-structural member. This system was initially used in the interior spaces in buildings, but it has gradually been applied as a loading member in building structures. To support the lateral stability of LSF, different methods are used such as shear wall systems and braced spans with diagonal steel ties.

Recently, research on LSF has been carried out worldwide to investigate the structural performance of differently shaped profiles or to evaluate seismic strength. Cold-formed steel (CFS) structures offer a lightweight and inexpensive alternative to traditional construction techniques, especially for low-rise, one- or two-storey residential buildings [1].

Construction using cold-formed steel sections has become very successful in Scandinavia and North America during the last few years. The construction differs from timber frame structures [2]. Although CFS walls are not new and have been used as non-structural partitions for decades [3], their application as main structural load-bearing components of frames is fairly new. As a result, guidelines that address the seismic design of CFS structures are not yet fully developed, and the design of these systems is not yet covered in detail in building standards. Among existing codes and standards, the NEHRP recommendation (FEMA 450) [4] specifies that the connection for diagonal bracing members and boundary members (chord members) shall have a design strength greater than or equal to the nominal tensile strength of the strap-bracing members. This recommendation also states that the pull-out resistance of screws shall not be used to resist seismic load because it does not allow the straps to develop their full tensile capacity (which is vital for the system's ductile performance in high seismic events).

According to NEHRP, diagonal braces and studs or chords supporting the brace force should be anchored such that bottom and top tracks are not required to resist uplift forces by bending of the track or track web. Both flanges of studs should be braced to prevent lateral-torsional buckling. The code also limits the low-rise story drift ratio to 2.5%, 2.0% and 1.5% for seismic use groups I, II and III, respectively. The US Army Corps of Engineers has published TI809-07 [2] that provides similar but more stringent regulations for the design of strap-braced CFS stud walls where straps are connected only to the frame's exterior corners and where chords

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* Corresponding author.
E-mail addresses: Hossein_aghabeik@yahoo.com (H. Mirzaaghabeik), vosoughifar@azad.ac.ir (H.R. Vosoughifar).

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are constructed from box sections. Other codes, such as ASCE7 [5] and IBC [6], refer to AISI standards [7–11] for lateral design, which are essentially similar to FEMA 450 [4] with no special guidelines regarding the design of new systems or any distinction between different types of strap-braced systems.

Fulop and Dubina [12] tested three double-sided X-strap braced wall panels with an aspect ratio of 1.5 (3.6 m length * 2.44 m height) under monotonic and cyclic loading. Serrette and Ogunfunmi [13] investigated the performance of 2.44 m * 2.44 m strap-braced CFS wall studs under a quasi-monotonic lateral load control regime. Gad et al. [14,15] investigated the seismic performance of strap-braced CFS wall studs with or without gypsum board cladding by means of experimentation (cyclic and shake table testing) and numerical studies. Pastor and Rodrıguez-Ferran [16] presented a hysteresis model for strap-braced CFS wall studs that are properly designed for seismic loading, i.e., frame detailing to allow sufficient yielding of straps prior to any failure at connections or any buckling. Al-Kharat and Rogers [17] investigated the inelastic performance of 16 strap-braced 2.44 m * 2.44 m CFS wall studs with double-section stitch-welded front-to-front chord members under a cyclic loading regime. Tian et al. [18] conducted experimental and analytical studies on the racking resistance and stiffness of CFS walls. Kim et al. [19] performed a shaker table test on a full-scale two-story one-bay CFS shear panel structure. Each storey consisted of two identical shear walls 2.8 m in length and 3.0 m in height separated from each other by 3.9 m centre to centre.

2. Network learning process

2.1. Definition of investigated braces

In this paper, braces have been divided into four groups as shown in Figs. 1–4.

2.2. Artificial neural network

The neural network as a parallel processor has been constructed from basic units named neurons to save and process experimental information. Determining the types of joints can be fully or partially adjoined to the design of a network. Network recurrence should be assessed. Feed-forward networks are usually used to calculate simple mathematical problems without dynamics. Recurrent networks are used in the majority of dynamic problems. The final goal

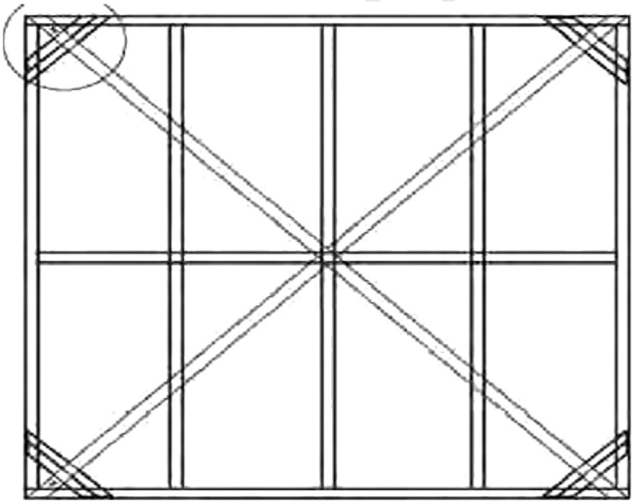

Fig. 1. A group.

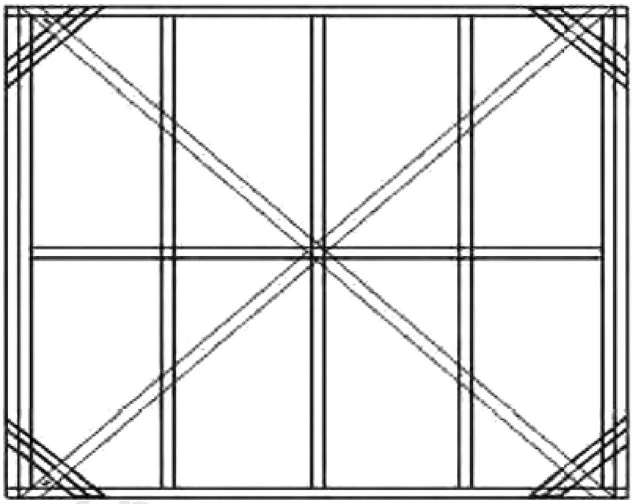

Fig. 2. B group.

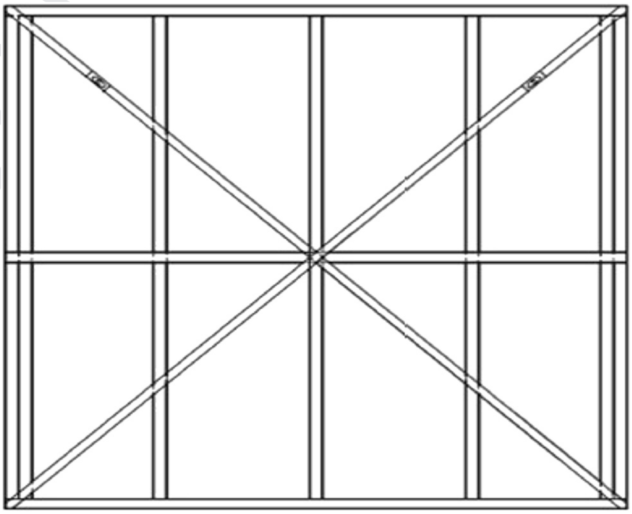

Fig. 3. C group.

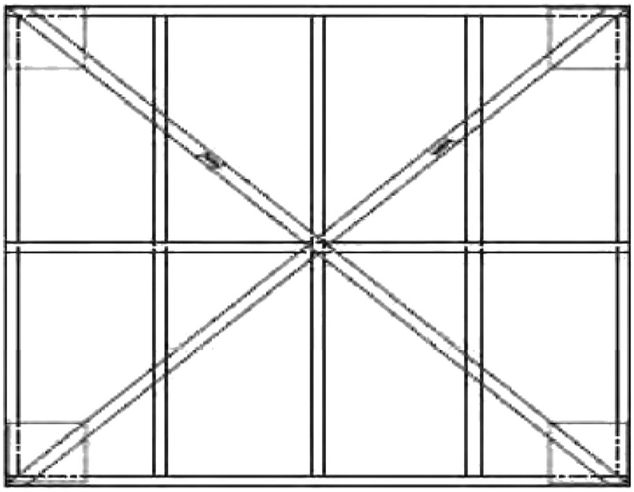

Fig. 4. D group.

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