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Original Research Article

Causes of imminent failure damage and repair of steel building purlins

A. Biegus *

Wrocław University of Technology, Department of Civil Engineering, Wrocław, Poland

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ABSTRACT

A systemic design of purlins made from Z-sections (cold-formed from sheet metal) and their ties (made from solid bars) had been adopted in the investigated steel building. A periodic survey of the latter's technical condition showed that the purlins were deformed, bent and twisted and the ties were buckled. The condition of the roof deck supporting structure posed an imminent failure hazard. This paper presents the results of investigations of the load-bearing capacity and rigidity of the roof deck supporting structure, the aim of which was to determine the causes of its imminent failure condition.

1. Introduction

The tested building is a single bay steel building. A periodic condition survey showed that the purlins were twisted and bent and their ties (nominally designed as tension members) were buckled. The alarming behaviour of the building roof deck supporting structure indicated its imminent failure condition.

This paper presents the results of tests of the load-bearing capacity and rigidity of the building roof deck supporting structure, the purpose of which was to determine the causes of the warping of the purlins and of the buckling of the ties. The building design incorporated the so-called systemic solutions for the roofing and the walls (both made from sandwich panels) and their supporting structure consisting of purlins and wall girts (both made from cold-formed plate metal sections).

The roof deck supporting structure made up of purlins and ties was incorrectly braced in the roof plane. Moreover, because of the improper connection the roofing plate did not protect the purlins from warping. In the considered case, the cause of the building failure hazard was the designer's inadequate knowledge of the shaping and constructing the lightweight sheathing of steel buildings and the lack of information about the conditions and limitations for using the purlin and roof panel systemic solutions found in the manufacturer catalogues. The supporting structures of the lightweight sheathing of steel buildings, made from slender-walled cold-formed plate metal sections (characterised by low rigidity of their cross sections against free torsion and bending relative to the "weak" axis), require an appropriate system of point braces in the form of ties, and antitorsional bracings [1–4]. In order to determine their behaviour and optimally and safely design such structures one must use complex analytical models, e.g. [5,6].

* *Correspondence to*: ul. Wybrzeże Wyspiańskiego 27, 50-377 Wrocław, Poland. Tel.: +48 664 531 931.
E-mail address: Antoni.Biegus@pwr.wroc.pl

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2. Description of steel building load-bearing structure

A schematic of the single bay steel building is shown in Figs. 1 and 2. Its on-plan dimensions are: width – about 23.57 m and length – about 57.40 m (Fig. 1). The building's roof is single sloped with a slope of 5%.

Transverse frames R with a span of 23.57 m, spaced at every 5.68 m are the building's load-bearing structures in the axes from B to M. Their single sloped roof girt is rigidly connected with the columns which at the bottom are hinged connected with the reinforced concrete structure of the building's bottom part. Frames R were designed as solid structures with their cross sections made from welded plates. Their girts were protected against warping with ''struts'' connected with purlins P.

In the gable walls (in axes A and N) the building's transverse load-bearing structures are structures made up of a single sloped roof girt and five intermediate columns. The columns are hinged connected both at their base and with the roof girt. No bracings were used in these transverse load-bearing structures, which is a fault. Therefore, in the design of the strengthening of this industrial building it was recommended to use an appropriate bracing.

Transverse (St1) and longitudinal (St2) slope bracings were used in the building's roof plane. Intercolumn bracings (St3) were used in the plane of the longitudinal walls. All the bracings are of type X and are made of solid bars with turnbuckles. The roof deck supporting structure (Fig. 2b) consists of purlins P and ties Sc.

Purlins P were designed as multispan continuous structures. Z-purlins made from cold-formed steel (S350) plate

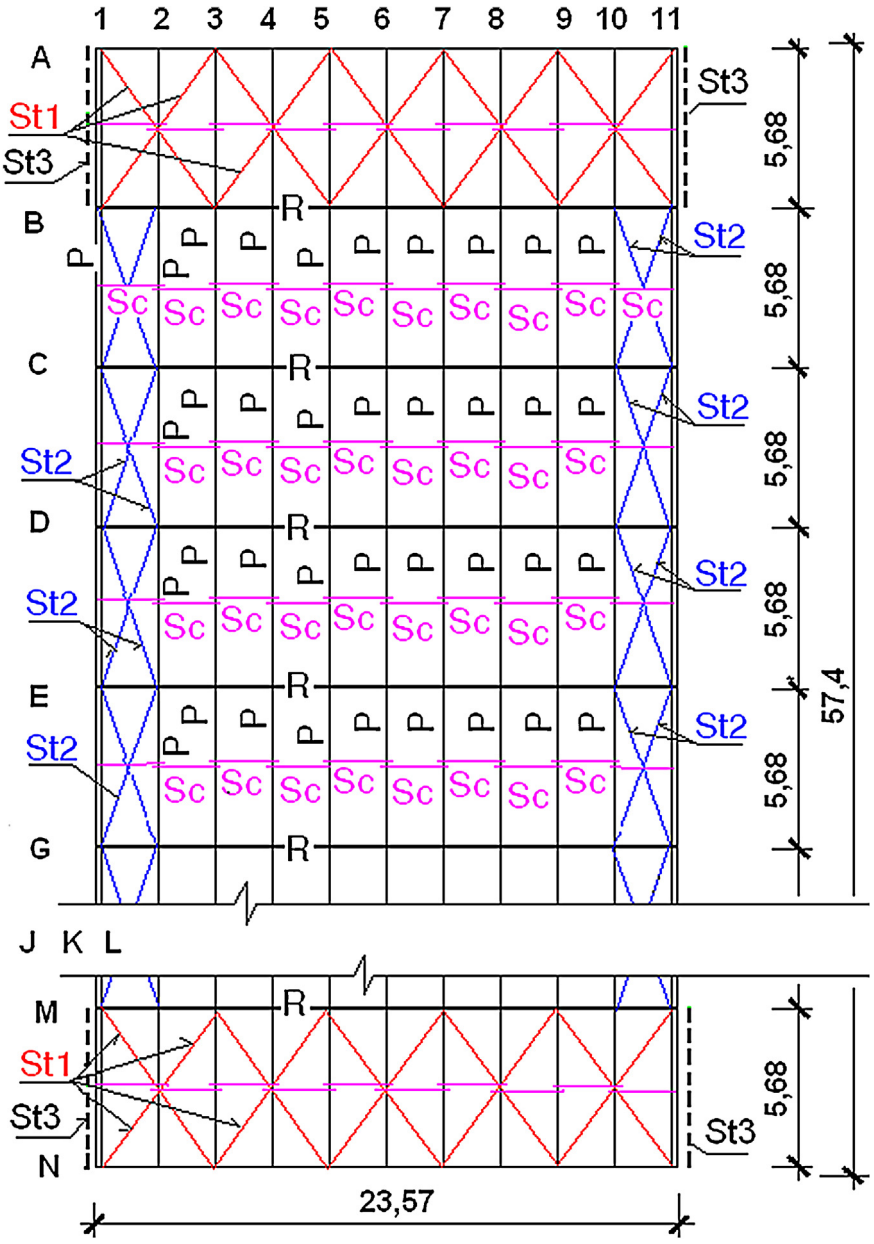

Fig. 1 – Schematic of load-bearing structure of steel building.