TRUSSED GLASS PLATES

UNTERSPANNTE GLASTAFELN

DALLES EN VERRE TREILLISSEES

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SUMMARY

The entrance area of the administration building of the Greschbach & Brake-Morat company was roofed by large-scale glass plates. In order to reduce the span of the laminated plates additional supports were provided by a truss. The truss bars were attached to the plates in specially designed nodes. The suitability of the structure and the materials was proved by tests.

ZUSAMMENFASSUNG

Der Eingangsbereich des neuen Verwaltungsgebäudes der Firma Greschbach & Brake-Morat wurde mit weitgespannten Glastafeln überdacht. Zur Verminderung der Spannweite der Verbundglasplatten wurden zusätzliche Auflager durch Anbringen einer Unterspannung geschaffen. Die Druck- und Zugstäbe wurden an besonders konstruierten Knoten mit der Glastafel verbunden. Durch Versuche wurde die Eignung dieser Konstruktion und der gewählten Werkstoffe nachgewiesen.

RÉSUMÉ

La zone d´entrée du bâtiment de l´administration de la société Greschbach & Brake-Morat était couverte d´un toit en verre. Afin de diminuer la portée des dalles en verres feuilletés des appuis supplémentaires étaient ajoutés par un treillis. Les barres de traction et compression étaient attachés au verre par des nœuds d´assemblage particuliers. L´aptitude de la construction et des matériaux choisis était prouvée par des essais.

KEYWORDS: glass structure, glass roof, laminated glass, trussed plate, node, material choice, resin, load-bearing capacity, creep deformation, test

1. INTRODUCTION

The Greschbach & Brake-Morat company built an administration building where the entrance area is covered by a glass roof (fig. 1). The main parts of the supporting construction consist of steel profiles forming a lattice structure suspended on pylons. Glass plates with dimensions 3800 mm x 1950 mm made of laminated heat strengthened glass panes are attached to the supporting structure only in four points in the corners. The spacing of the fixing points in longitudinal direction is 2900 mm meaning a span of the plate of the same amount. This statical system would lead to uneconomic glass thicknesses. In order to reduce the span four additional supports per glass plate are provided by a truss yielding a maximum span of 1m. A glass plate thickness of 2 x 8 mm was choosen which proved to give a sufficient load-bearing capacity to carry the dead load and loads caused by snow.

In addition to loads acting perpendicular to the pane surface, in-plane loads caused by the truss are introduced into the glass plate at the outer fixing points. These fixations are the most critical points of the whole structure and the task was given to construct such a node, to choose appropriate materials and to prove their suitability by tests.

2. NODE CONSTRUCTION

The node consists of a continous thread bolt leading through a hole in the glass panes. Two circular steel plates are attached to the steel rod clamping the glasses. Silicone layers are arranged between the steel plates and the glass to avoid the direct contact. So far this construction is able to carry forces perpen-

dicular to the panes.
In-plane forces are introduced into the glass plates by bolt bearing pressure in the glass hole. To avoid direct contact between the glass and the metal the thread bolt is encased by a cylindrical steel shell and the gap between the shell and the glass is filled with a two component resin (patent pending construction).

The resin is able to level out the terraced unevenness of the wall of borehole which is a consequence of manufacture tolerances. In both glass panes of a laminated element the boreholes are not located just at the same places. There are always some inaccuracies of about 1mm. Fig. 3 gives some details of the node.

3. TESTS

In the tests both loading directions were treated separatively.
Only a few tests were carried out to determine the load- bearing capacity perpendicular to the glass plate. In the tests glasses with the dimensions 600mm x 600 mm were mounted on circular wooden supports with diameter d = 545 mm, simulating the corner area of the real structure supported along the estimated zero moment line and with the fixation in its centre (fig. 4).
The majority of tests were dealing with in-plane forces and particularly with the transient and long-term behaviour (creep) of the resin. Several transient tests were performed at ambient temperature and after water immersion (11 days, bath temperature 60°C). The location of the circular shell varied within the glass hole. As a consequence the gap between steel shell and glass (equals the thickness of the resin) ranged between 2 mm and 10 mm.

Simulating the worst case tests with direct contact steel-glass were carried out with specimens without resin. Long-term tests (2000 hours) were performed at ambient temperature and elevated temperature (60°C) with three different load levels

$F_1 = 1{,}5$ kN	(line a)
$F_2 = 3{,}0$ kN	(line b)
$F_3 = 4{,}5$ kN	(line c)

4. TEST RESULTS

In the test with loads acting perpendicular to the glass panes failure loads in the range of 7 kN to 8,3 kN occured. Both glass panes of the laminated elements were damaged but a sigificant residual flexural stiffness due to the fragment bonding behaviour of the PVB-layer (polyvinylbutyral) was observed. In the case of fully damaged glasses a sufficient load bearing capacity of the trussed glass sheet is therefore presumed.
The transient tests with loads parallel to the glass surface at ambient temperature and after water immersion were terminated at the peak load of 10 kN without any sign of damage to the glasses.
The long-term creep behaviour of the resin is characterized by a nearly linear monotonic increase of the deformation versus the logarithm of time. After 2000 hours (12 weeks) the creep deformation reached 1.2 mm ($F_1 = 1{,}5$ kN). Accompanying finite element analysis showed that such deformations don´t cause significant stress variations in the glass plate.
After unloading of the test specimens recovery was observed (fig.5).
The tests with bolt bearing pressure acting on the glass without a resin layer

showed an early failure (min F = 4.5 kN) of one glass pane that had contact with the steel bolt due to the terraced shape of the borehole. Despite this failure the applied load could be increased. The cracks in the damaged pane propagated or new cracks developed but no total failure occured up to the termination of the tests when the load reached 10kN.

5. CONCLUSIONS

In order to reduce the span of glass plates additional supports are provide by a truss. As a consequence the glass plate has to carry loads acting perpendicular to the glass surface like dead load and snow and in-plane loads introduced at the outer fixing points. The investigation focussed on the fixing points which consist of a continous steel rod, two circular steel plates, silicone layers and a resin filling to avoid the contact between the bolt and the glass. Several tests with transient and long-term loading at ambient and elevated temperature conditions were performed to prove the suitability of the construction and the materials. The test results together with accompanying finite element calculations indicated a safe load-bearing capacity of the structure and give emphasis for further research and application in the field of long-span glass plates.

REFERENCES

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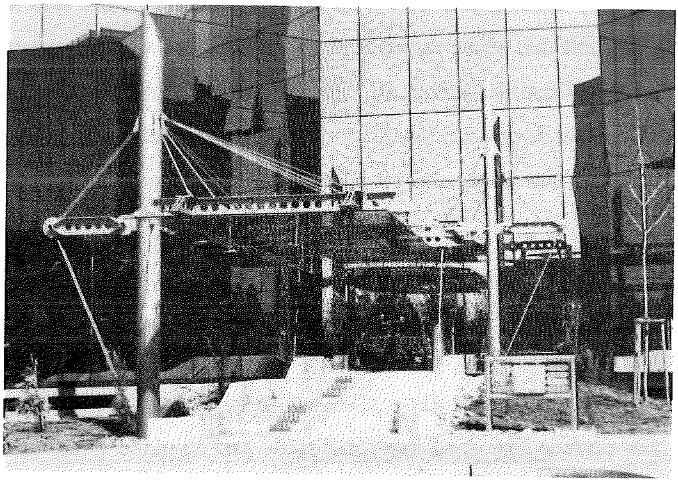

Fig.1 Entrance area of the administration building

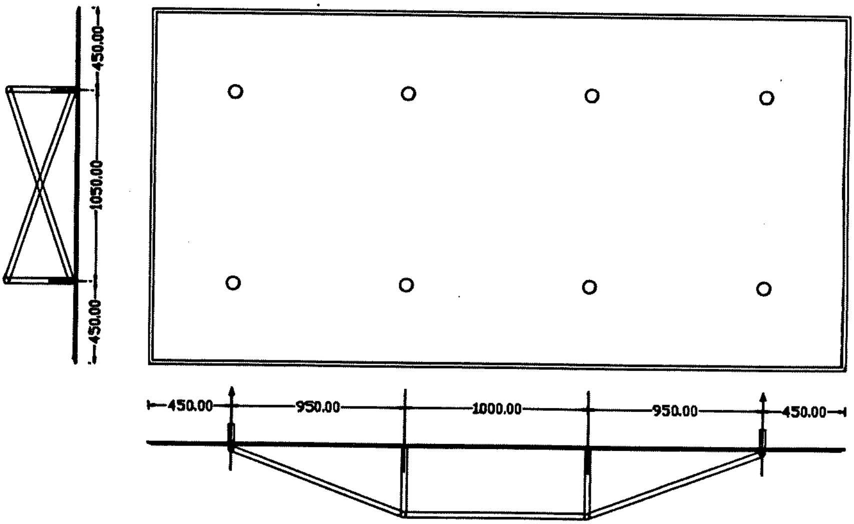

Fig.2 Dimensions of the trussed glass plates

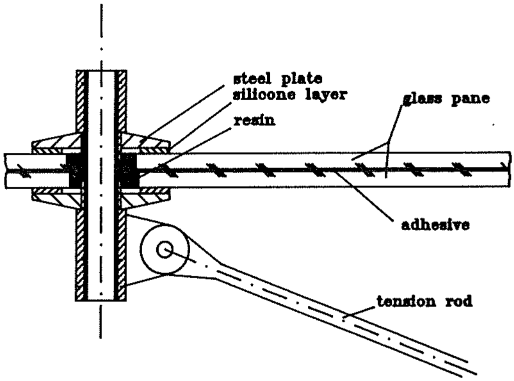

Fig.3 Node dimensions

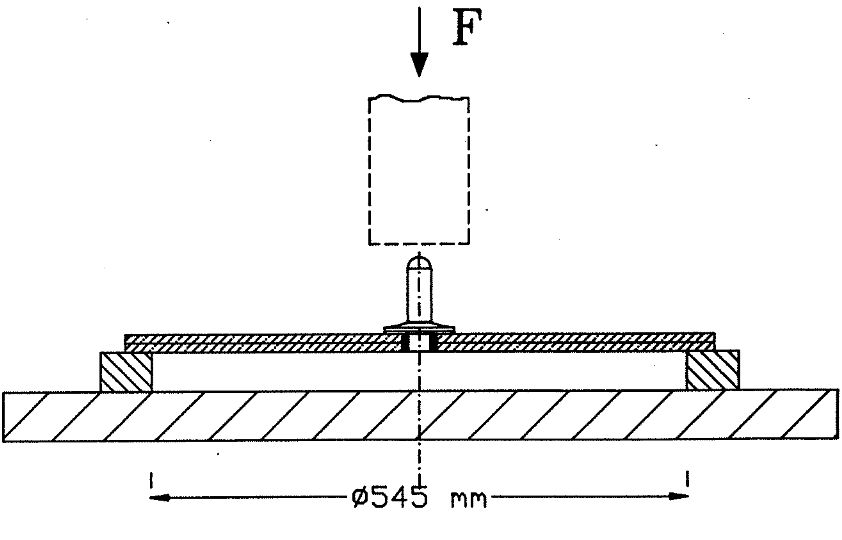

Fig.4 Test set-up for loading glass plates perpendicular to the surface

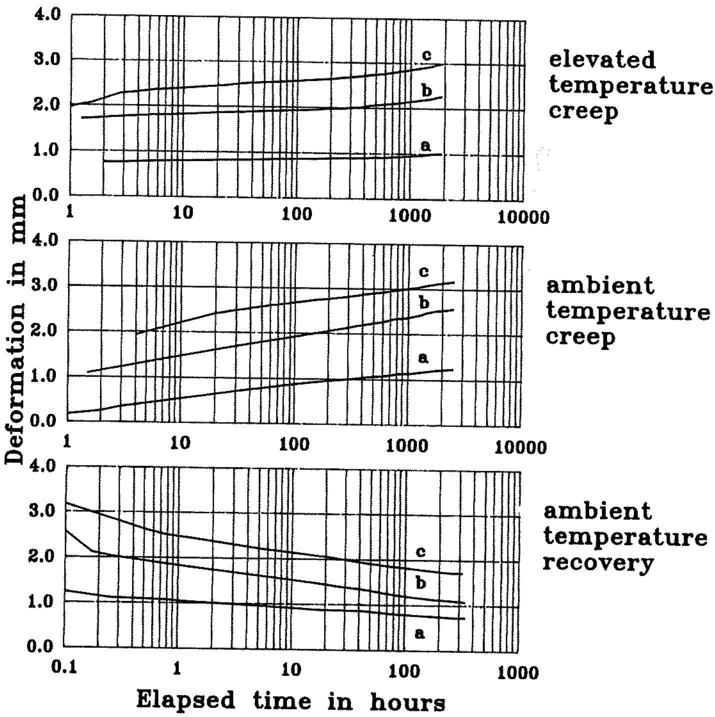

Fig.5 Creep and recovery capacity of the resin at different load levels and ambient conditions