Effect of Traffic Loading on the Long-Term Behaviour of Geogrids

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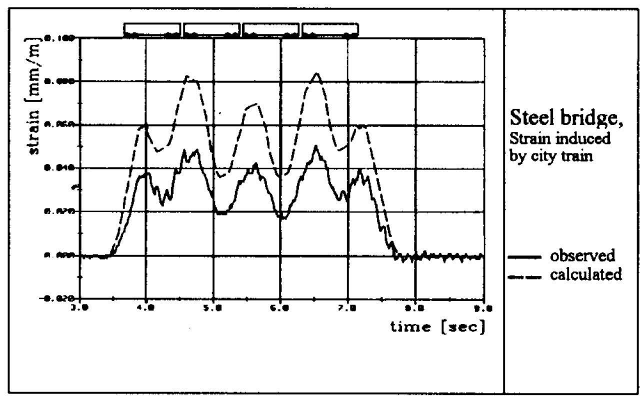
ABSTRACT: Geosynthetic reinforced structures are loaded not only under sustained loads, but especially in traffic structures subject to dynamic loading. Response frequencies of 5, 25, 50 Hz are referred from German railroad authorities. For these frequencies tests were designed to investigate the long-term behaviour of geogrids, especially long-term strength. A comparison of specimens loaded with 3 static loads representing upper. lower and mean load of a dynamic cyclic sinusoidal loading and specimens loaded dynamically show creep-deformations slightly higher than those of the static mean load. The tests lasted for 1000 h; i.e. more than 10 millions cycles.

1 INTRODUCTION

Geogrid-reinforced structures are accepted by German authorities only under "mainly static loads" as very little is known about the behaviour under dynamic loading. In tests at the Institut für textile Bau- und Umwelttechnik (tBU)/Fachhochschule Münster the dynamic loading of structures was evaluated and tests were performed to generate information on the response of geosynthetics to dynamic loading and it's effect on long-term strength.

2 DYNAMIC LOADING

Structures are subjected to single dynamic events such as earthquakes, vehicle impact or repeated events, e.g. passing trains, planes, vehicles, machine vibration. (Trampe Brock).



Source: Dr.-Ing. K. Brandes VDI, Berlin/Din VDI Berichte 940 Strain measurements on old steel bridges for assessing the remaining fatigue life IMEKO/GESA Symposium Düsseldorf 1992

Figure 1: Stress distribution under a train passing a bridge

This report deals with intermittent cyclic loading as to be found on all traffic structures. For bridges the dynamic response is normally the resonance frequency (values between 0.1 and 10 Hz) (Müller-Rochholz/Weber). Typically these events are plotted as time curves or frequency spectrum (see fig. 1).
For railroads on embankments the observed frequencies are primarily close to the excitation values. On the bases of average axle distances, train speed and support distances the frequencies observed have 3 main values (Blum/Lieberenz). These are 5 Hz, 25 Hz and 50 Hz with very low deformation amplitudes.

3 POLYMER BEHAVIOUR

The effect of cyclic loading on materials is fatigue. In building structures the fatigue design stress is the maximum stress which can be applied to a material an infinite number of times without fatigue failure. For a limited number of cyclic loading applications a fatigue service life may be taken from the resulting Wöhler curve (Wesche). Polymers are reported to have good resistance to cyclic loading with increasing strain amplitudes at constant stress amplitudes (Sächtling). The measured strain amplitudes are low enough to ensure that the critical fatigue stesses are not reached (Blum).

The remaining question therefore, is whether and by how much additional cyclic loading influences the long-term strength.

4 TEST DESIGN AND DYNAMIC LOADING APPARATUS

To obtain results independent of test environment, the static and dynamic load creep tests were undertaken in a temperature controlled laboratory. During the tests both the air and specimen temperatures were recorded. The applied dynamic loads were set with a maximum amplitude of 25 % of the long-term characteristic strength (f_k) of the geogrid reinforcement. The products tested was the extruded and stretched HDPE Tensar SR80 geogrid.The dynamic loading regime used comprised F_m with a dynamic load of $\pm$ 12.5 % f_k.

The dynamic load was applied using eccentric mass vibrators, calibrated by using a load cell in place of the geogrid specimen.

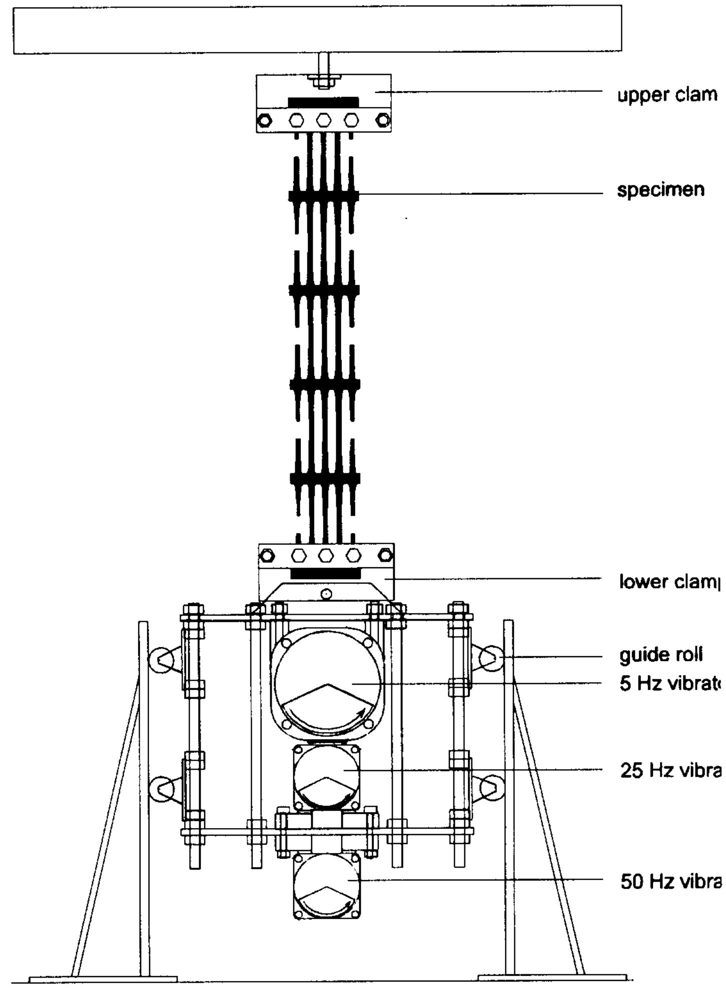


Figure 2: Loading device

For the static loads S_{max}, S_{mid}, S_{min} creep tests were performed (one specimen each). With the dynamic forces D_{max}, D_{mid}, D_{min}, 24 h and 1000 h duration tests were performed.

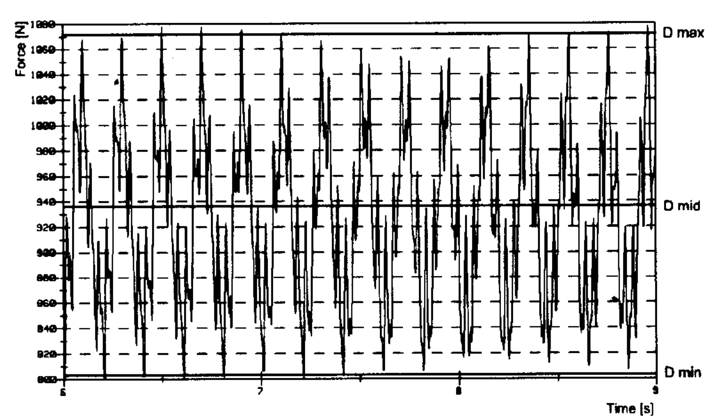


Figure 3: Load-time-curve

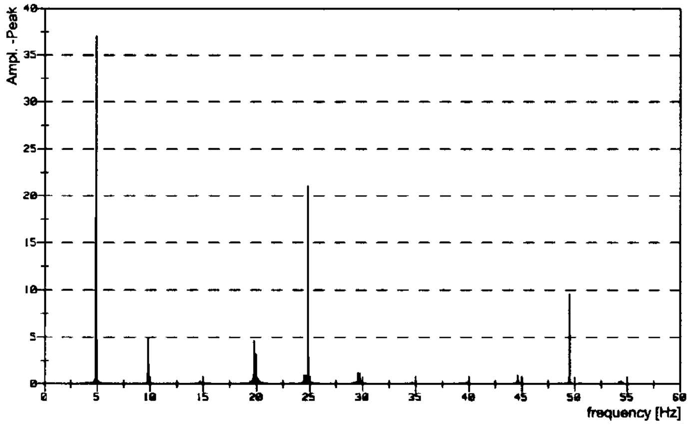


Figure 4: Fourier on FFT-Spectrum

5 RESULTS

The resulting deformation versus time plots (given in fig 5 as linear time plot and fig 6 with a logarithmic time axis) show the known behaviour under sustained static load (curves S_{max}, S_{mid}, S_{min}).

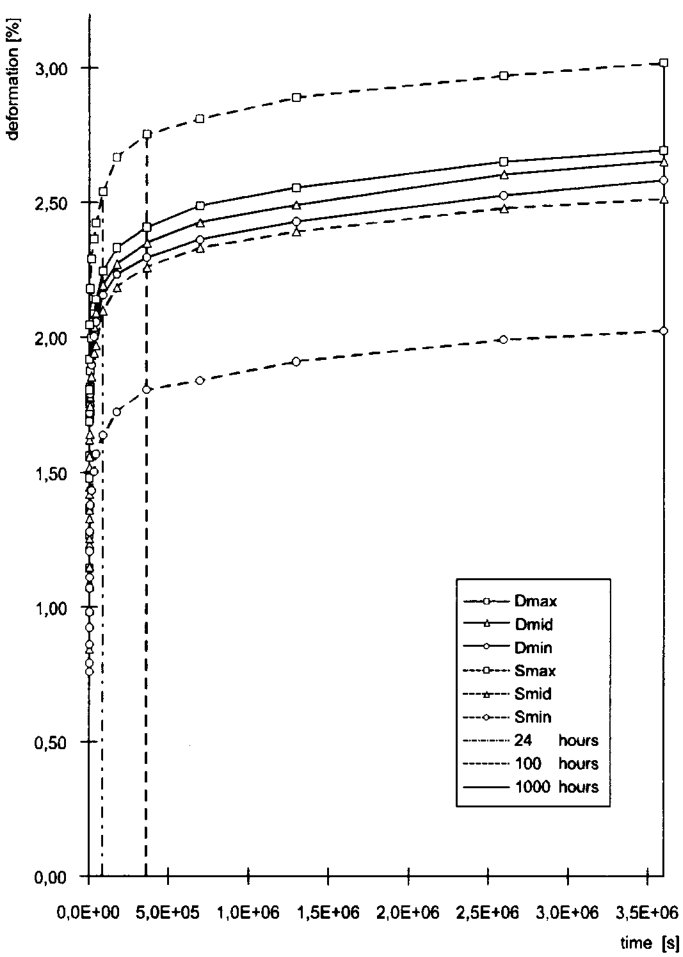
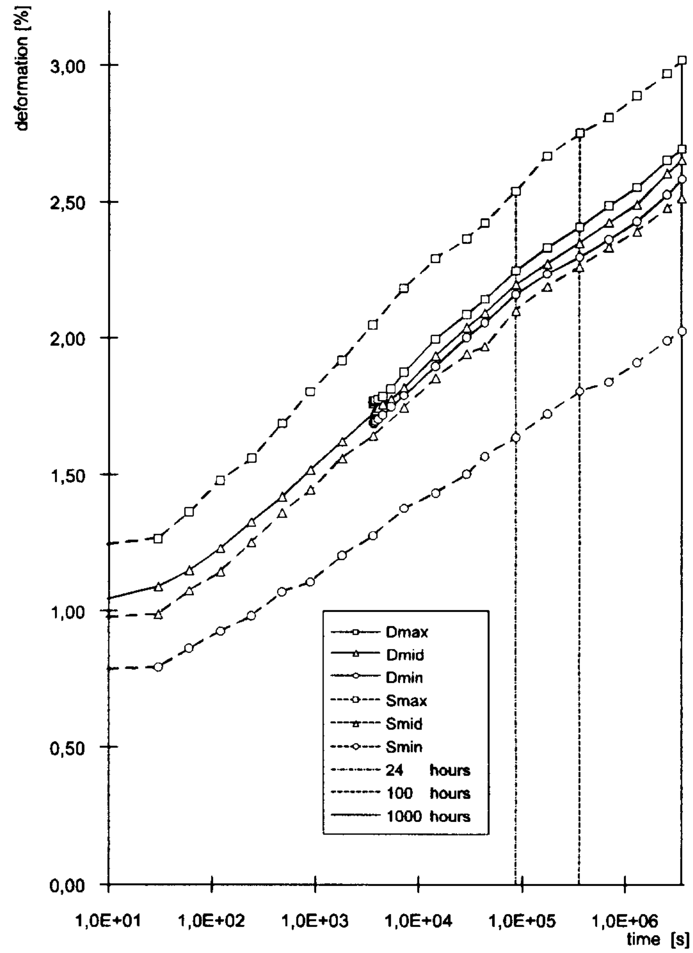


Figure 5

The deformation under combined static and dynamic loading between $D_{min} = S_{min}$ and $D_{max} = S_{max}$ show curves slightly higher than S_{mid} the mean value of dynamic loading.



Up to 1000 h dynamic loading (these are cycle numbers of about 10^7 for 5 Hz, 10^8 for 25 Hz and 50 Hz) there is no significant influence of the dynamic load on creep performance; in fact if peak load is constant, the dynamically loaded specimen shows less creep; creep deformation for this load history is close to the static deformation of mean level of load.

6 REFERENCES

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