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SANDWICH STRAIN GAUGES USED ON SHELL STRUCTURES

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ABSTRACT

The article deals with use of sandwich strain gauges on thin-walled structures for an experimental verification of deformations and stresses in places of structures, accesible from one side only. Use of a common strain gauge would limit a problem to determination of a total stress and strain in a place of a strain gauge only without possibility to provide stress categorization for better stress assessment.

INTRODUCTION

An experimental methods play an important role in analysis of a civil engineering structures. The experimental method, using measurement of strains by help of strain gauges is one of the most important experimental methods namely in filed of steel structures. A method mentioned is used either for a verification of results of numerical analysis of a structure or for an investigation of a strain and stress state of a structure, for which the numerical analysis is impossible to use from any reasons.

A use of strain gauges is namely important in case of a thin-walled structures, see lit.[1], where strain gauges are placed on an opposite sides of the shell wall to allow a decomposition of measured values into two part, a membrane part and a bending one. It is important for a possibility to assess measured values in frame of a stress categorization as it is used e.g. in the american standard ASME Code and in other national standard. In a case, when a location of strain gauges on opposite sides of a shell wall is not possible, a use of so called „sandwich" strain gauges takes place. An utilization of sandwich strain gauges is demonstrated in the article on the big capacity oil storage tank, see lit. [2].

THE METHOD DESCRIPTION

The scheme of a sanwich strain gauge is shown in the Pict. 1. This type of a strain gauge is bonded on one side of a plate, on both sides of a sandwich strain gauge two simple strain gauges are placed on an opposite sides. A linear distribution of a strain over wall section is seen in Pict. 1. Here from a similarity of triangles it is possible to express the strain ε_3 on the base of two measured values of strains ε_1 and ε_2. Also it is possible to express two components of strain, first one ε_a corresponding to an axial force N, (a membrane state) and a second one ε_b corresponding to a bending moment M, (a bending state). This strain decomposition is important for a possibility to assess stresses by so called *stress categorization,* see lit. [3]. The relations used for such a decomposition are introduced in the following:

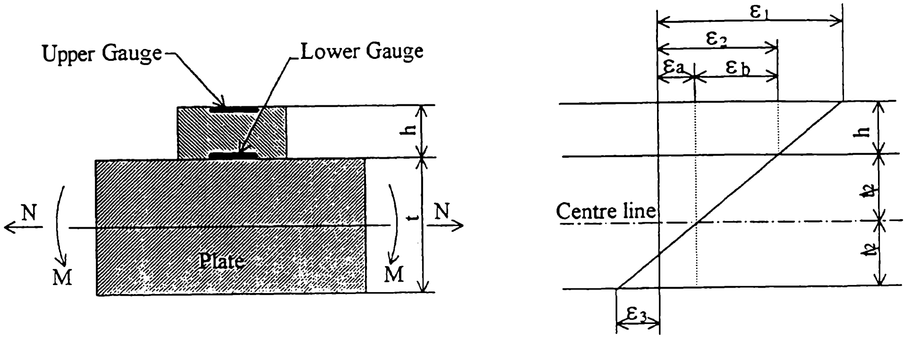
$$\varepsilon_b = \frac{t}{2h}.(\varepsilon_1 - \varepsilon_2)$$

$$\varepsilon_a = \varepsilon_2 - \frac{t}{2h}.(\varepsilon_1 - \varepsilon_2)$$

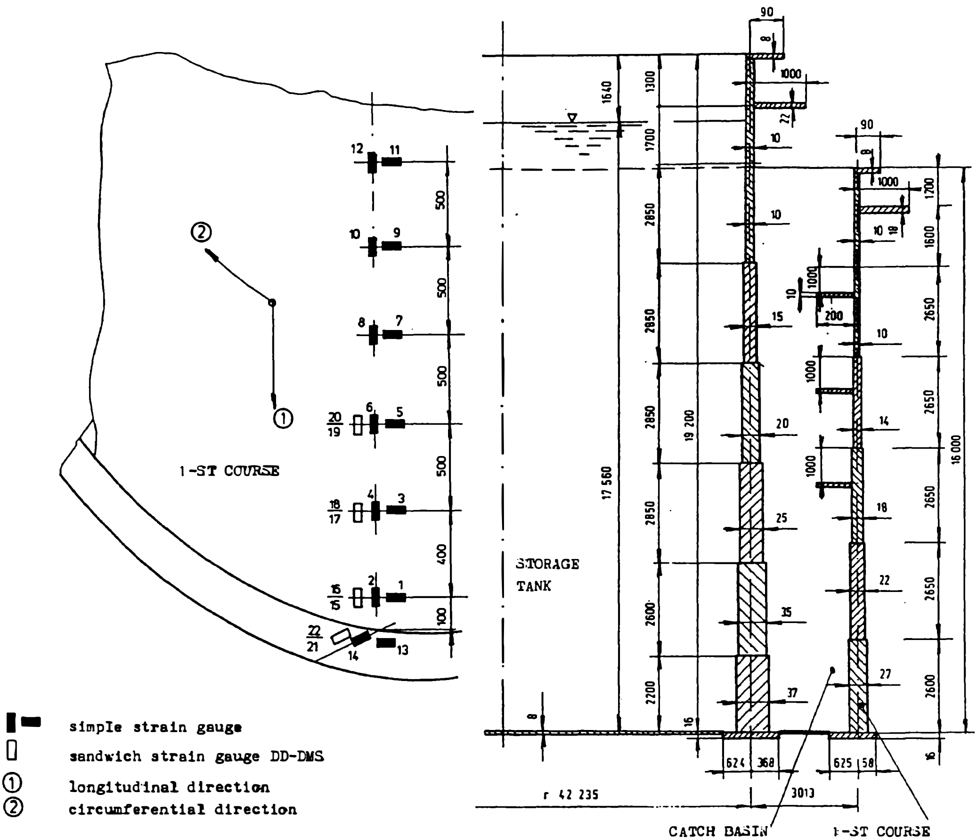
$$\varepsilon_3 = \varepsilon_2 - \frac{t}{h}.(\varepsilon_1 - \varepsilon_2)$$

A STORAGE TANK MEASUREMENT

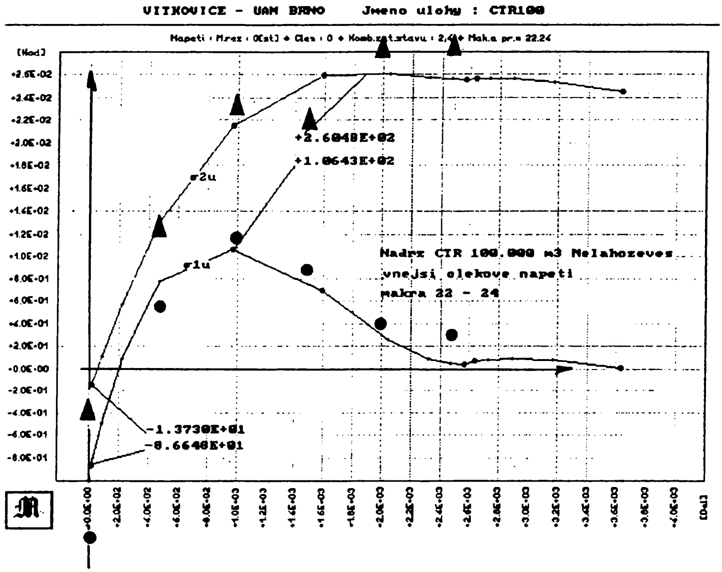
The method described was used to measure strains on a large storage oil tank (100.000 m^3). The meridian of a tank together with strain gauges location is seen in Pict. 2. Both types of strain gauges are used here, a simple one (measurement of longitudinal and circumferential direction on the ouside tank surface) and a sandwich one (longitudinal direction on outside tank surface only). The aim of measurement was to check so called *the bending disturbance* on the tank shell wall in the vicinity of the tank bottom, known also as *the edge effect.* The strain gauges measurement was provided for a hydrostatic load of the catch basin by a water fill with the hight of water level $H = 15.45\ m$. The stress distribution along the storage tank meridian, gaind and computed from strain gauge reading in both longitudinal and circumferential directions is drawn in Graph 1 as the individual points. The comparison with the numerical analysis, provided by numerical method FEM is given in that graph. Strain gauges of points 1 to 12 are of a single type, while points 15 to 20 are of sandwich type DD-DMS. The check of edge effect (longitudinal bending moment M_l), obtained by above issued relations is seen in Graph 2.



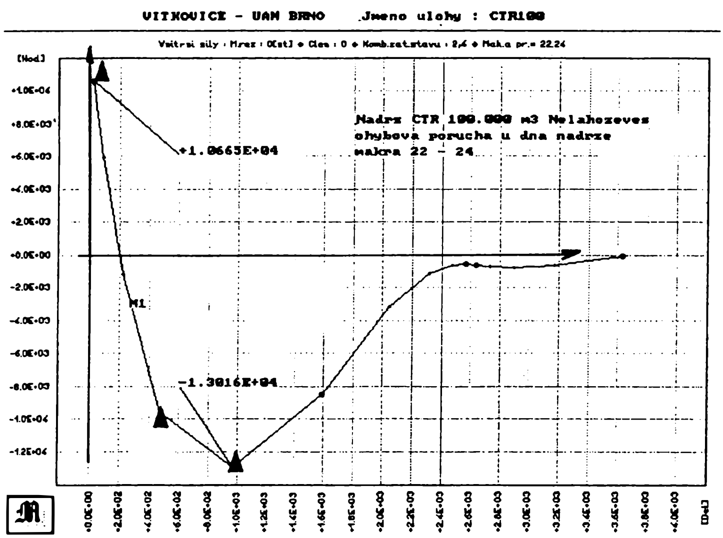
Picture 1



Picture 2



Graph 1: Total outside stresses σ_{1u} and σ_{2u} of the tank 1-st course



Graph 2: Bending moment M_1 of *the edge effect*

DISCUSSION

As it is seen in Graph 1 and 2 the measured stresses correspond in a good manner to stresses, gaind by a numerical method (FEM). To provide a measurement of strains on an inside wall surface would require pro provide a good insulation against water activity. A little wörse accurace, according to practical knowledge, is obtained in case of loads, recalling a low strain level. On the contrary for relatively high strain level (0.2%) the strain gauge readings accuracy is falling, caused by the sendwich strain gauge base material. A use of these types of strain gauges completes in a good maner an investigation of a strain and stress state of measured structure and verifies experimentally results of a numerical computer analysis especially in cases, where an opposite side of a masured place is inaccessible one.

REFFERENCES

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