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POSSIBILITY OF APPLICATION OF THE SIMULATION BASED ASSESSMENT METHOD IN MODELLING OF STRUCTURES

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1. Introduction

The article deals with an ability to assess the reliability of structural element on its model by means of the simulation based reliability assessment SBRA Method. The aim is to present a possibility of judgement of probability of failure of real component on its model. A simply supported steel beam of rectangular cross section area loaded by a simple concentrated force F (Fig. 2) was taken into account as a model of real steel beam. That model was available. That´s why that opposite approach was chosen when for the existing model actual corresponding beam was searched using rules of modelling. Using modelling rules the bending stresses were determined in the real beam using experimentally determined strains and stresses in the model. Stresses of steel beam and its model were determined using SBRA Method too and that method was used for judgement of their probability of relatively simple failure. Obtained results were compared.

The simulation Based Reliability Assessment Method is a probabilistic method using the Monte Carlo simulation [**1, 3**]. Substance of that method consist in repeated calculations of relatively simple equations, where variables as dimensions of the body, mechanical properties, loads, etc. can be insert. That variables can be constant or defined by histograms, respectively. Probability of failures of model and real beam were determined using Anthill software [**3**].

Modeling of engineering problems can be very often a way to solve them. It is generally based on the conditions

$$\left(\pi_i\right)_S = \left(\pi_i\right)_M\,,\quad i = 1,\,2,\,...,\,m \qquad (1)$$

where π_i are so called dimensionless parameters for structure (subscript S) and model (subscript *M*).

$$\pi = x_1^{e_1}\; x_2^{e_2}\; .....x_n^{e} \qquad (2)$$

If the solved problem depends on n variables x_i (expressing physical, geometrical etc. quantities). Exponents e_i, $i = 1,\,2,\,..,\,n$ has to fulfil the condition of dimensionless of π terms, see [2].

$m = n - r$ represents number of independent π terms, *r* is rank of so called dimensional matrix, see [2]. There is assumed that solved problem is described by *n* physical quantities x_i, $i = 1,\,2,\,..,\,n$ containing *k* so called primary quantities with primary units $\lfloor L_j \rfloor$, $j = 1,\,2,\,..,\,k$. The necessary procedure is described in [2].

Probability of failure is guided by so called safety function, see Fig. 1.

$$P_{f(i)} = R_{(i)} - S_{(i)} \qquad (3)$$

Where **S** is the load effect And **R** is the structural resistance. The probability of failure P_f of a body can be then expressed as a ratio between the number N_f of results that do not fulfil the defined before safety function and the total number of results that do not fulfil the defined before safety function N_f and N_t, is total number of results [1].

$$P_f = N_f / N_t \qquad (4)$$

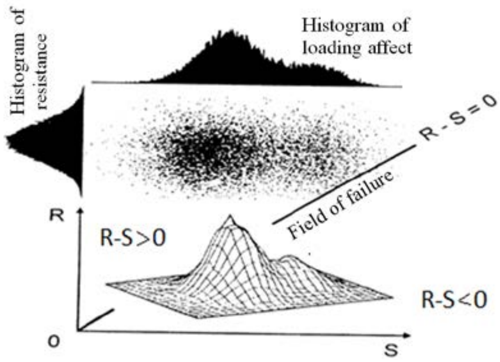

Fig. 1. Probability of failure.

2. Experimental results

The used steel model is stated in Fig. 2 Loading forces were F=100, 200, 300, 400, 450 N. Strains were measured using electrical-resistance gages. Their positions are obvious in Fig. 2. Recorded values of strains and corresponding stresses are, in the Tab. 1.

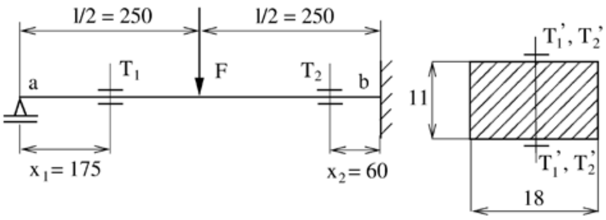

Fig. 2. Model of the beam.

To determine corresponding state in real steel beam length of the beam l=2500mm and rules of modelling were used and loading forces F_B and section modulus W_B were determined. Material of model and of real beam was the same therefore stresses in the model and in the real beam are the same, steel S235 with Young´s modulus of elasticity $E = 2{,}1 \cdot 10^5$ MPa, see the Tab. 1.

	F_m[N]	**300**	**450**
Model experiment	$2\varepsilon_{1m} \cdot 10^{-3}$	0,225	0,33
	σ_{1m} [Mpa]	47,25	69,30
	$2\,\varepsilon_{2m} \cdot 10^{-3}$	-0,165	-0,26
	σ_{2m} [Mpa]	-34,65	-54,6
Beam	**F_B**[kN]	7,5	11,25

Tab. 1. Results of the Modell and of the beam

F_m[N]	**300**		
F_B[kN]	**7,5**		
	MODEL exp.	**SBRA-m**	**SBRA-B**
$2\varepsilon_{1m} \cdot 10^{-3}$	0,225	-	-
$2\varepsilon_{2m} \cdot 10^{-3}$	-0,165	-	-
σ_1 [MPa]	47,25	45,190	45,202
σ_2 [MPa]	-34,65	-34,289	-34,195
$\sigma_{1Det.}$[MPa]	45,2		
$\sigma_{2Det.}$[MPa]	-35,82		

m - **Model**, B – **Beam**, Det. – **beam determined**

Tab. 2. Results of Modell and of SBRA simulation.

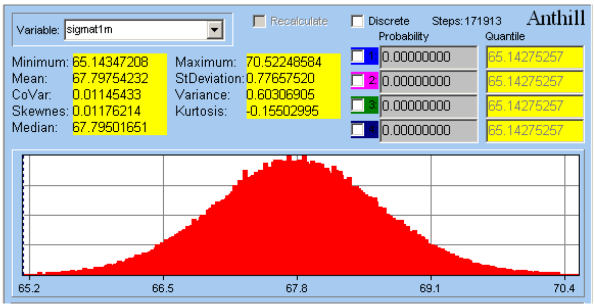

Fig. 3. The resulting stress σ_{1m} [MPa].

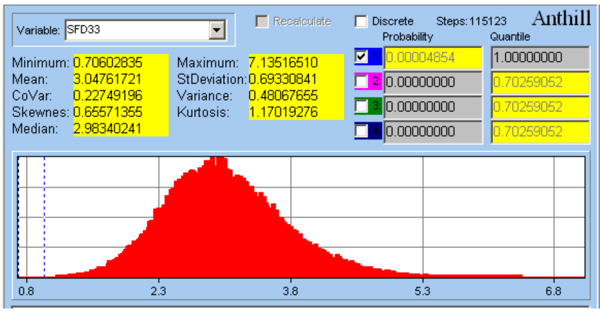

Fig. 4. Probability of failure Pf(i), SF(i).

In Fig.3 there is for illustration presented histogram of the resultant stress of the model and in Fig. 4. histogram of probability of failure.
Probability of failures of the beam determined using SBRA method were $\mathbf{P}_{f(i)B} = 4{,}8 \cdot 10^{-5}$ and for the model $\mathbf{P}_{f(i)m} = 4{,}103 \cdot 10^{-5}$.

Obtained results show very good correspondence. It gives a sure possibility for determination of failure probability of structure to determine it using corresponding model.

Acknowledgements

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