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THE REDESIGN FEATURES OF EXISTING STRUCTURES

A residual survival probability of members and systems of existing structures subjected to extreme service and climate actions is considered. The time-dependent safety margin of particular members (sections, bars, connections) and its modifications as stochastic finite sequences are discussed. The prediction of primary and revised instantaneous and long-term survival probabilities of members is introduced. The effect of deterministic short-term extreme action effects on the values of revised survival probabilities of existing members is based on the concepts of truncated resistance distributions and Bayesian statistical approaches. The revised reliability index of precast concrete floor slabs is considered and demonstrated by the numerical example.

Introduction. For successful ordinary and scheduled maintenances of existing structures, it is necessary to know the revised values of their time-dependent survival probability parameters. The extreme action effects caused by service and climate loads help engineers convince in the absence of rough human design and construction errors. Besides, the fixed values of random extreme action effects assist designers reduce the uncertainties of a performance of particular members (sections, bars, connections) of structures and in this way to revise their survival probability degrees.

Additional information about unfavorable actions and behaviors of overloaded members cannot be used in their capacity assessment. However, information data may be successfully used in the probabilistic reliability prediction of members and systems. It is very possible that the high-reliability degree of structures should be guaranteed if they had already withstood unfavorable extreme loading situations. Thus, extreme action effects of members may be treated as an effective measure in the updated reliability prediction of existing members and their systems when they are confirmed by quality statistical information data (Mori & Ellingwood 1993). These data may help designers refine probability density functions of member resistances if their variances are small (Melchers 1999).

There are some limited attempts to transfer the approaches of deterministic limit state design to the quality analysis of existing structures (Allen 1991). However, this semi-probabilistic reliability analysis format cannot be acknowledged as an universal, convenient and practical method. Therefore, it is expedient to realize the information on service-proven loading situations in engineering practice using probabilistic approaches (Madsen 1987, Ellingwood 1996, Melchers 1999). They allow evaluate objectively all uncertainties of calculation models, design situations and structural performance parameters. However, it is difficult to apply these approaches in engineering practice due to some methodological and mathematical difficulties. Probability-based approaches may be acceptable to structural engineers only under the indispensable and easy perceptible condition that they may be translated into practice using unsophisticated analysis models.

The intention of this paper is to introduce engineers and researchers the concepts of truncated probability distribution and Bayes theorem in the revised reliability prediction of members of existing structures subjected to extreme actions as intermittent rectangular renewal pulse processes.

1.Structural reliability asessment

1.1. Structural safety margins

According Melchers (1999) and JCSS (2000) recommendations, the time-dependent random safety margin of particular members of structures may be defined as their performance process:

$$Z(t) = g\left[X(t), \theta\right] \tag{1}$$

Here the function $g[\bullet]$ is founded by structural mechanics rules, where $\boldsymbol{X}$ and θ are the vectors of basic and additional random variables representing a resistance and action effects of members and their model uncertainties, respectively.

In the contest of the analysis of survival probabilities of members of existing non-deteriorating structures in transient design situations, the process (1) may be presented in more convenient form:

$$Z(t) = \theta_R R - \theta_g S_g - \theta_q S_{q_s}(t) - \theta_q S_{q_e}(t) - \theta_w S_w(t) \tag{2}$$

where R is a member resistance as the stationary process; S_g, S_{q_s}, S_{q_e} and S_w are the action effects caused by permanent g, sustained q_s and extraordinary q_e live loads and lateral (wind) pressure w (Fig.1). The additional variables θ_i may be introduced by their means and standard deviations equal to $\theta_m = 1.0 - 1.05$ and $\sigma\theta = 0.05 - 0.10$ (Hong & Lind 1996, Stewart & Rosowsky 1996, JCSS 2000, Vrowenvelder 2002).

According to the recommendations of international design codes (ISO 2394 1998, EN 1990 2002, JCSS 2000), a Gaussian distribution law is to be used for permanent actions. Lognormal, Weibull and Gamma distributions may be convenient for sustained live loads and an exponential distribution for extraordinary ones (JCSS 2000, Vrowenvelder 2002, Trezos & Thomos 2003). Annual extreme climate actions may be modeled by a Type 1 (Gumbel) distribution of extreme values (Melchers 1999, JCSS 2000).

Not only annual extreme wind w and snow s loads but also the annual extreme sum of stochastic sustained and extraordinary live loads $q(t) = q_s(t) + q_e(t)$ may be modeled as a rectangular renewal pulse process and described by a Type 1 distribution with the coefficient of variation $\delta q = 0.58$ and mean value $q_m = 0.47 q_k$, where q_k is its characteristic value (Rosowsky & Ellingwood 1992).

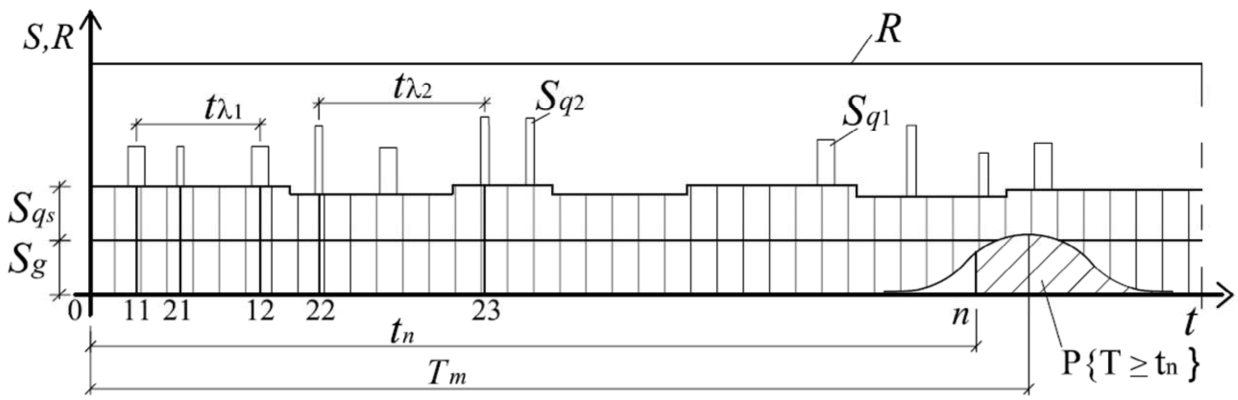

Fig. 1 Model for the time-dependent reliability nalysis of particular and individual members.

For the sake of simplified but fairly exact probabilistic analysis, it is more expedient to present equation (2) in the forms:

$$Z_1(t) = R_{c1} - S_1(t) \tag{3}$$

$$Z_2(t) = R_{c2} - S_2(t) \tag{4}$$

Here

$$R_{c1} = \theta_R R - \theta_g S_g \tag{5}$$

$$S_1(t) = \theta_q S_q(t) + \theta_w S_w(t) \tag{6}$$

$$R_{c2} = \theta_R R - \theta_g S_g - \theta_q S_{q_s} \tag{7}$$

$$S_2(t) = \theta_q S_{q_e}(t) + \theta_w S_w(t) \tag{8}$$

where R_{c1} and R_{c2} are the conventional resistances of members; $S_1(t)$ and $S_2(t)$ are their total annual extreme action effects. The extreme live action effects $\theta_q S_q(t) = \theta_q S_{q_s}(t) + \theta_q S_{q_e}(t)$ and $\theta_q S_{q_e}(t)$ may be modeled respectively by Gumbel and exponential distributions. In the reliability analysis of roof structures, the action effect $\theta_s S_s(t)$ should be used instead of the component $\theta_q S_q(t)$ caused by floor loads.

1.2. Structural survival probability

For structures subjected to intermittent extraordinary gravity or lateral actions, the design cuts of safety margin processes coincide with extreme loading events. Therefore, in design practice the stochastic safety margin of particular members may be treated as the random finite sequence:

$$Z_k = R_c - S_k,\ k = 1, 2, \dots, n-1, n \tag{9}$$

Here R_c is given by Equations (5) or (7), S_k by (6) or (8); $n = t_n \lambda$ is the recurrence number of recurrent extreme action effects during the design working life of structures t_n, where λ is a renewal rate of these effects.

The instantaneous and long-term survival probabilities of particular members may be calculated respectively by the Equations:

$$\boldsymbol{P}_k = \boldsymbol{P}\{Z_k > 0\} = \boldsymbol{P}\{R_c > S_k\} = \int_0^\infty f_{R_c}(x) F_{s_k}(x) dx \tag{10}$$

$$\boldsymbol{P}_i = \boldsymbol{P}_k^n \left[1 + \rho_{kl}^a (1/\boldsymbol{P}_k - 1)\right]^{n-1} \tag{11}$$

Here $f_{R_c}(x)$ is the density function of conventional resistances by Equations (5) or (7); $F_{S_k}(x)$ is the cumulative distribution function of action effects by (6) or (8); ρ_{kl} is the coefficient of auto correlation of cuts of safety margin sequences the bond index of which is $a \approx [4{,}5/(1-0{,}98\rho_{kl})]^{1/2}$.

When the action effects by Equations (6) and (8) are caused by two extreme loads, three stochastically dependent sequences of safety margins should be considered as follows:

$$Z_{1k} = R_c - S_{1k};\ k = 1,2,\dots,n_1 \tag{12}$$

$$Z_{2k} = R_c - S_{2k};\ k = 1,2,\dots,n_2 \tag{13}$$

$$Z_{3k} = R_c - S_{3k};\ k = 0,\dots,n_3 \tag{14}$$

Here the recurrent number of coincident extreme action effects S_{1k} and S_{2k} may be calculated by the formula:

$$n_3 = t_n (d_1 + d_2) \lambda_1 \lambda_2 \tag{15}$$

where d_1, d_2 and λ_1, λ_2 are the durations and renewal rates of extraordinary loads (Fig.1). In this case, the long-term survival probability of members as rank series stochastic systems with the probabilities $\boldsymbol{P}_1 > \boldsymbol{P}_2 > \boldsymbol{P}_3$ may be introduced as:

$$\boldsymbol{P}_m = \boldsymbol{P}\left\{\bigcap_{i=1}^{3} Z_i > 0\right\} = \boldsymbol{P}_1 \boldsymbol{P}_2 \boldsymbol{P}_3 \times \left[1 + \rho_{3/21}^a \left(\frac{1}{P_2} - 1\right)\right] \times \left[1 + \rho_{21}^a \left(\frac{1}{P_1} - 1\right)\right] \tag{16}$$

where P_i is given by Equation (11); $\rho_{3/21} = 0.5(\rho_{31} + \rho_{32})$ is the coefficient of rank correlation of three safety margins.

Analogically, the total survival probabilities of rank series systems consisted of r stochastically dependent members may be expressed as:

$$\boldsymbol{P}_s = \boldsymbol{P}\left\{\bigcap_{j=1}^{r} Z_j > 0\right\} = \prod_{j=1}^{r} \boldsymbol{P}_{mj}\left[1+\rho^a_{r/r-1...1}\left(\frac{1}{\boldsymbol{P}_{r-1}}-1\right)\right]\times\left[1+\rho^a_{k/k-1...1}\left(\frac{1}{\boldsymbol{P}_{k-1}}-1\right)\right]\times...\times\left[1+\rho^a_{21}\left(\frac{1}{\boldsymbol{P}_1}-1\right)\right] \quad (17)$$

where $\rho_{k/k-1...1} = (\rho_{k,k-1} + ... + \rho_{k1})/(k-1)$ is the coefficient of cross correlation of rank safety margins of members.

2.Revised structural safety prediction

2.1. Acount of truncated distribution approaches

When an additional information permit to define the deterministic value S_{tr} of extreme action effects $\theta_e S_e$ (either $\theta_q S_{q_e}$ or $\theta_s S_s$ or $\theta_w S_w$) caused by live, snow and wind loads, the prediction of instantaneous survival probabilities of members may be based on the concept of truncated probability distributions (Fig. 2). In this case, the density function of revised conventional resistances of members R_{cr} should be considered as a truncated one. It may be presented as:

$$f_{R_{cr}}(x) = f_{R_c}(x)/\left[1 - F_{R_{cr}}(x)\right] \quad (18)$$

The mean and variance of this resistance a probability distribution of unrevised values of which, R_c, is close to a normal distribution may be expressed as:

$$R_{cr,m} = R_{cm} + \lambda\sigma R_c \quad (19)$$

$$\sigma^2 R_{cr} = \sigma^2 R_c\left[1 + \lambda(\beta_{tr} - \lambda)\right] \quad (20)$$

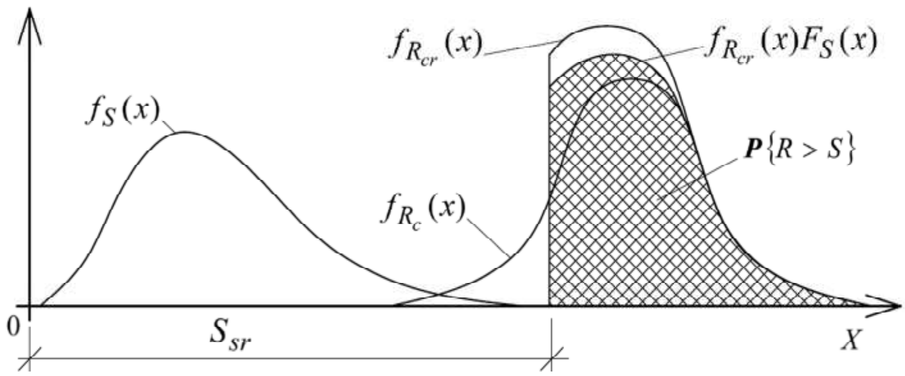

Fig. 2 Model for the revised structural safety analysis of members.

Here the conversional factor of its statistical moments is:

$$\lambda = \varphi(\beta_{tr})/\left[1 - \Phi(\beta_{tr})\right] \quad (21)$$

where $\varphi(\beta_{tr})$ and $\Phi(\beta_{tr})$ are the density and cumulative distribution functions of a standard normal distribution of the variable $\beta_{tr} = (S_{tr} - R_{cm})/\sigma R_c$.

The revised instantaneous survival probability of members whose successfully have withstood unfavourable extreme action effects may be expressed as:

$$\boldsymbol{P}_{kr} = \boldsymbol{P}\{R_{cr} > S_k\} = \int_0^\infty f_{R_{cr}}(x) F_{S_k}(x)dx \quad (22)$$

The revised long-term survival probabilities of members and systems during their residual service life may be calculated respectively by equations (16) and (17) using the revised values of instantaneous survival probability of members expressed by (22).

2.2. Acount of Bayes theorem

According to Tang (1973) and Madsen (1987) recommendations, the updated probability of failure of members can be expressed as follows:

$$\boldsymbol{P}_{kr} = \boldsymbol{P}\{Z_k > 0 \mid H\} = \frac{\boldsymbol{P}\{Z_k > 0 \cap H > 0\}}{\boldsymbol{P}\{H > 0\}} \tag{23}$$

Here the design and inspection instantaneous safety margins of considered members are:

$$Z_k = \theta_R R - \theta_g S_g - \theta_q S_{q_s k} - \theta_e S_{ek} \tag{24}$$

$$H_k = (\theta_R R)_k - \theta_g S_g - \theta_q S_{q_s k} - S_{tr} \tag{25}$$

where S_g, $S_{q_s k}$ and S_{ek} are the action effects caused by random loads where $S_{ek} = S_{qe}$, $S_{ek} = S_{sk}$ and $S_{ek} = S_{wk}$; S_{tr} is the deterministic value of observed extreme action effect; $(\theta_R R)_k$ is the characteristic resistance of a member.

The means and variances of the safety margin functions and the coefficient of their correlation are:

$$Z_{km} = (\theta_R R)_m - (\theta_g S_g)_m - (\theta_q S_{qk})_m - (\theta_e S_{ek})_m \tag{26}$$

$$H_{km} = (\theta_R R)_k - (\theta_g S_g)_m - (\theta_q S_{qk})_m - S_{tr} > 0 \tag{27}$$

$$\sigma^2 Z_k = \sigma^2(\theta_R R) + \sigma^2(\theta_g S_g) + \sigma^2(\theta_e S_{ek}) + \sigma^2(\theta_q S_{qk}) \tag{28}$$

$$\sigma^2 H_k = \sigma^2(\theta_R R) + \sigma^2(\theta_g S_g) + \sigma^2(\theta_q S_{qk}) \tag{29}$$

$$\rho_{ZH} = \rho(Z_k, H_k) = \sigma H_k / \sigma Z_k \tag{30}$$

When an indispensable condition $H_{km} > 0$ is in force, the inspection instantaneous survival probability of considered members is:

$$\boldsymbol{P}_{tr} = \boldsymbol{P}\{H_k > 0\} = \Phi(H_{km} / \sigma H_k) \tag{31}$$

According to the method of transformed conditional probabilities, Equation (23) may be rewritten as follows:

$$\boldsymbol{P}_{rk} = \frac{\boldsymbol{P}\{Z_k > 0\}\boldsymbol{P}\{H_k > 0 \mid Z_k > 0\}}{\boldsymbol{P}\{H_k > 0\}} \approx \boldsymbol{P}\{Z_k > 0\}\left[1 + \rho_{ZH}^{a \cdot \boldsymbol{P}_{tr}} \cdot \left(\frac{1}{\boldsymbol{P}\{Z_k > 0\}} - 1\right)\right] \tag{32}$$

This value of instantaneous survival probability is used in the prediction of long-term survival probabilities of members and systems calculated by Equations (16) and (17).

2.3. Numerical illustration

Consider the revised survival probability of concrete floor slabs overloaded by the deterministic extreme bending moment $M_{tr} = 140$ kNm caused by the extraordinary service live load. The means and variances of their bending resistance and bending moments caused by permanent, sustained and extraordinary service loads are:

$$(Q_R R)_m = 300 \text{ kNm}, \ \sigma^2(Q_R R) = 1989 \ (\text{kNm})^2,$$

$$(Q_g M_g)_m = 90 \text{ kNm}, \ \sigma^2(Q_g M_g) = 162 \, (\text{kNm})^2,$$

$$(Q_q M_{q_s})_m = 18 \text{ kNm}, \ \sigma^2(Q_q M_{q_s}) = 162 \, (\text{kNm})^2,$$

$$(Q_q M_{q_e})_m = 28 \text{ kNm}, \ \sigma^2(Q_q M_{q_e}) = 784 \, (\text{kNm})^2.$$

The probability distribution of the conventional resistance of slabs by Equation (7) is close to the normal distribution. Mean and variance are:

$$R_{cm} = 300 - 90 - 18 = 192 \text{ kNm},$$

$$\sigma^2 R_c = 1989 + 162 + 162 = 2313 \, (\text{kNm})^2.$$

According to Equation (21), the conversional factor of truncated resistance distribution is equal to $\lambda = \varphi(-1{,}0812)/\Phi(1{,}0812) = 0{,}2585$. Thus, the revised statistical moments by (19) and (20) of the member resistance are:

$$R_{cr,m} = 192 + 0{,}2585(2313)^{1/2} = 204{,}43\,\text{kNm},$$

$$\sigma^2 R_{cr} = 2313[1 + 0{,}2585(-1{,}0812 - 0{,}2585)] = 1511{,}98\ (\text{kNm})^2,$$

$$(\theta_R R)_k = 300(1 - 1.645 \times 0.1) = 250{,}65\ \text{kNm}.$$

Here $(\theta_R R)_k$ is characteristic resistance of slabs.

According to Equations (26)–(29), the statistical moments of design and inspection safety margins are:

$$Z_{km} = 300 - 90 - 18 - 28 = 164\ \text{kNm},$$

$$H_{km} = 250 - 90 - 18 - 140 = 2\ \text{kNm} > 0,$$

$$\sigma^2 Z = 1989 + 162 + 162 + 784 = 3097\,(\text{kNm})^2,$$

$$\sigma^2 H_k = 1989 + 162 + 162 = 2313\,(\text{kNm})^2.$$

According to Equations (30) and (31), the coefficient of correlation of these margins and the inspection instantaneous survival probability of the member are: $\rho_{ZH} = [2313/3097]^{1/2} = 0{,}864$ and $\boldsymbol{P}_{tr} = 0{,}522$. The extraordinary live bending moment M_{qe} is modeled by an exponential distribution. Thus the design value of instantaneous survival probability of slabs by Equation (10) is: $\boldsymbol{P}\{Z_k > 0\} = 0{,}99542$. It corresponds to the reliability index $\beta_k = \Phi^{-1}(P\{Z_k > 0\}) = 2.60$.

The revised values of instantaneous survival probabilities of slabs the analysis of whose was based on the concepts of truncated probability distribution and Bayes theorem are calculated respectively by Equations (22) and (32). They are equal to $\boldsymbol{P}_{rk1} = 0{,}99821$, $(\beta_{\boldsymbol{k1}} = 2.91)$ and $\boldsymbol{P}_{rk2} = 0{,}99845$, $(\beta_{\boldsymbol{k2}} = 2.96)$ respectively. The numerical integration and Bayes theorem methods gave the near values of survival probabilities. However, equation (32) may overestimate the revised reliability index of considered members (Fig. 3).

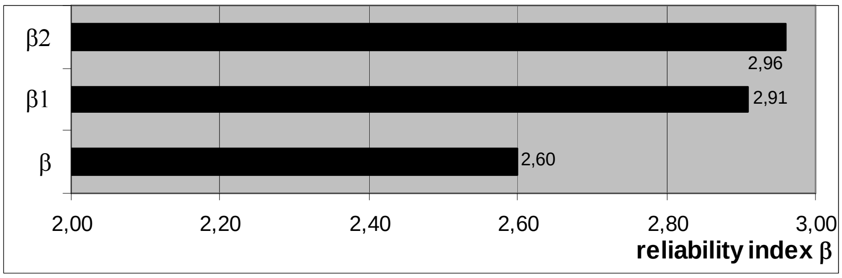

Fig. 3 Instantaneous and revised reliability indexes of slabs

3.Technical service life prediction

3.1. <u>Effect of structural features</u>

The minimum values for reliability index β_{min} associate with the structures. Therefore, the durability prediction of structures should be considered for beams, columns, slabs, piles, joints and other structural members as auto systems representing their multicriteria failure mode due to various action effects and responses of particular members. A necessity to use auto system models in design practice illustrated in Fig.4.

According to the method of transformed conditional probabilities, the total survival probability of structural members as series, parallel and mixed auto systems may be respectively calculated by the Equations:

$$\mathbf{P}_{ser}=\mathbf{P}_{ser}\{T\geq t_n\}=\mathbf{P}\{Z_1>0\bigcap Z_2>0\}=\mathbf{P}_1\mathbf{P}_2\left[1+\rho_{12}^{x}\left(\frac{1}{\mathbf{P}_{1/2}}-1\right)\right] \quad (33)$$

$$\mathbf{P}_{par}=\mathbf{P}_{par}\{T\geq t_n\}=\mathbf{P}\{Z_1>0\bigcup Z_2>0\}=\mathbf{P}_1+\mathbf{P}_2-\mathbf{P}_1\mathbf{P}_2\left[1+\rho_{12}^{x}\left(\frac{1}{\mathbf{P}_{1/2}}-1\right)\right] \quad (34)$$

$$\mathbf{P}_{mix}=\mathbf{P}_{mix}\{T\geq t_n\}=\mathbf{P}\{Z_1>0\bigcup Z_2>0\bigcap Z_3>0\}=\mathbf{P}_{par}\mathbf{P}_3\left[1+\rho_{3,21}^{x}\left(\frac{1}{\mathbf{P}_{3/par}}-1\right)\right] \quad (35)$$

Here $\mathbf{P}_{1/2}$ and $\mathbf{P}_{3/par}$ are the greater value from the probabilities $\mathbf{P}_1,\mathbf{P}_2$ and $\mathbf{P}_3,\mathbf{P}_{par}$ calculated by (11) and (34); $\rho_{3,21}=0.5(\rho_{12}+\rho_{13})$ is the coefficient of rank cross-correlation.

The technical service life t_t as a quantitative durability parameter of ageing structural members may be calculated from Equations (33)-(35). The computation is iterated until the value t_t corresponds the target probability $\mathbf{P}_{min}=\Phi(\beta_{min})$.

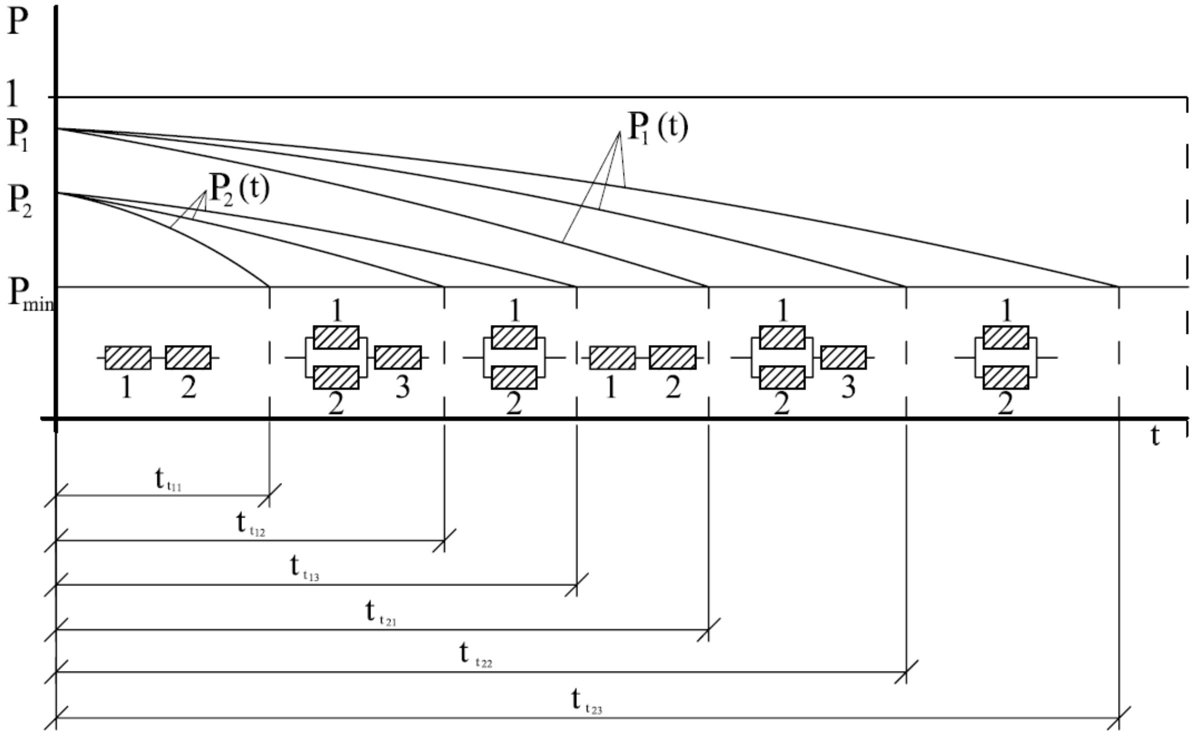

Fig. 4 Effect of auto system types and initial survival probabilities on the technical service life, t_t, of structural members

3.2. Numerical illustration

The procedure of technical service life prediction is applied to the roof beams of single storey buildings the deterioration function of whose is: $\varphi(t)=1-0.004(t-t_{in})$, where $t_{in}=12$ years is the initiation period of ageing process. The mean and variance of beam resistance in initial period are: $R_{in,m}=387.6\,kNm$, $\boldsymbol{\sigma}^2 R_{in}=(0.128\times 387.6)^2=2461.4$ $(kNm)^2$. The means and variances of bending moments caused by permanent and snow loads are: $M_{gm}=77.7$ kNm, $\boldsymbol{\sigma}^2 M_g=(0.10\times 77.7)^2=60.4\,(kNm)^2$; $M_{Sm}=15.21\,kNm$, $\boldsymbol{\sigma}^2 M_s=(0.60\times 15.21)^2=83.28\,(kNm)^2$.

The values of additional variables are: $\theta_{Rm} = \theta_{Mm} = 1.0$, $\boldsymbol{\sigma}^2\theta_R = \boldsymbol{\sigma}^2\theta_M = 0.01$. Therefore, the revised variances of beam initial resistances and bending moments may be presented: $\boldsymbol{\sigma}^2(\theta_R R) = 3963.8\,(kNm)^2$, $\boldsymbol{\sigma}^2(\theta_M M_g) = 120.8\,(kNm)^2, \boldsymbol{\sigma}^2(\theta_M M_s) = 85.56\,(kNm)^2$.

The parameters of beam conventional resistances are: $R_{ck,m} = \varphi_k\, 387.6 - 77.7\, kNm$ and $\boldsymbol{\sigma}^2 R_c = $ $= \boldsymbol{\sigma}^2(\theta_R R) + \boldsymbol{\sigma}^2(\theta_M M_g) = 4084.6\ (kNm)^2$ as constant value during the service life of beams.

The time-dependent beam reliability index $\beta(t) = \Phi^{-1}(\mathbf{P}) = \Phi^{-1}(\mathbf{P}\{T \geq t\})$ was calculated using Equation (11). According to Figure 5, the technical service life of deteriorating beams is equal to 30 years.

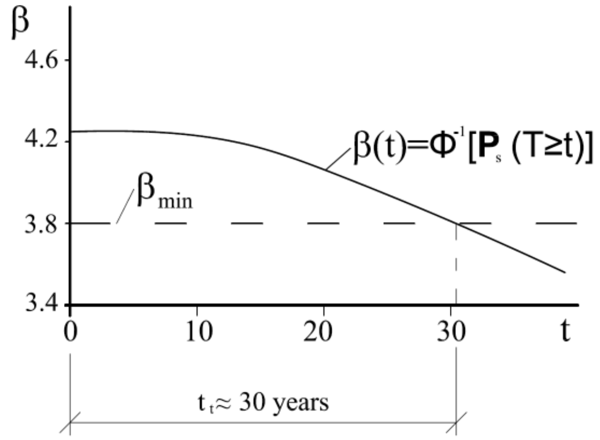

Fig. 5 Determination of beam technical service life t_t using the time-dependent reliability index curve

The curve of Figure 5 shows that the moderate relative deterioration of beams in structural resistance equal to 0.4 % /year may be rather dangerous.

Conclusion. The revised structural safety parameters of existing structures lead to correction of their technical service life and allow avoid both unexpected failures and unfounded premature repairs. However, it is rather difficult to revise objectively the design values of structural resistance and survival or failure probability of members and their systems. When unfavourable service-proven action effects caused by extreme live or climate actions are defined and confirmed by quality statistical information data, the revised safety parameters of structures may be assessed and predicted fairly exactly by presented engineering probabilistic approaches.

Generally, the extreme action effects of structures caused by service and climate loads are modeled as intermittent rectangular renewal pulse processes. Thus, the safety margins of particular members (sections, bars, connections) may be treated as random sequences. The revised values of instantaneous survival probabilities of particular members (sections, bars, connections) may be analyzed by Equations (22) and (32) based on concepts of their conventional resistance, truncated probability distribution and Bayes theorem approaches. These values may be successfully used in the prediction of long-term survival probabilities of members and systems during their residual service life using Equations (16) and (17) based on the concept of transformed conditional probabilities.

The presented approaches for revised probabilistic safety assessment and prediction of existing structures may be successfully used in engineering design practice.

The technical service life of structural members as a period of time of their safe performance at a preset reliability index represents a quantitative durability parameter of structural members. This parameter may help us to design sustainable buildings with balanced reliability indices of deteriorating structures and in this way fulfilled the durability requirements presented in design codes and standards.

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FACTORS INFLUENCED ON HEAT GAINS AND HEAT LOSSES IN BUILDINGS

The paper presents the results of investigations on building's heat gains and heat losses. The heat balance conditions in selected buildings were observed. The factors, which influence heat gains and heat losses in analysed building were identified. The changes of value of these quantities on the influence of individual factors were estimated.

Introduction. As far as heat gains are concerned, a factor that positively influences heat balance of the building is solar radiation. Both radiation duration and radiation rate are limited. About 80% of the total insolation concerns spring and summer months [1]. During the heating season an average sum of total solar radiation amounts to 1.44 kWh/m^2/24 hrs. Some heat gains result from the existence of additional heat sources connected with the utilisation of building. The gains come from people staying in the building, electrical and gas equipment as well as lighting.

Heat losses in a building result from heat penetration through external and internal partitions as well as from heating up the air exchanged in the ventilation process. Heat lost on penetration has been up till now the highest value in the annual loss account. With low thermal insulation of partitions it amounted to 80%. The observed and predicted increase of thermal insulation of external coating of buildings causes high dependence of heat losses on the ventilation needs. Heat lost on ventilation with air-tight enclosures amounts to 70–80%. Wind is a significant factor intensifying losses. At the speed of 3 m/s heat losses increase 2%, and with 6 m/s exceed by 25% the value of losses as compared to the windless weather. The shape and location of a building has a considerable influence on the whirl and wind velocity. The shape of the building determines as well its energy properties. Precipitation causing dampness of partitions and deterioration of their thermal insulation increases heat losses.