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I

The influence of thermal forces on the structural form

L'influence des forces thermiques sur le système et la forme d'une structure

Der Einfluss thermischer Einwirkungen auf das System und die Form eines Tragwerks

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SUMMARY
In this report it.is summarized how the design of structures is being influenced by thermal effects. At first the changes of the material properties under increased as well as low temperatures are being described. Further on remarks are given how imposed deformations caused by thermal effects may be decreased respectively avoided or be taken into consideration by constructional and design measures.

RESUME
Cette contribution montre l'influence des effets thermiques sur le projet de bâtiments. Le changement des propriétés des matériaux de construction est présenté pour des températures et basses. Des indications sont données sur la façon d'annuler les dérformations imposées, produites par les actions thermiques: ceci peut être obtenu par la prise en compte dans le calcul et par des mesures constructives.

ZUSAMMENFASSUNG
Der Beitrag gibt einen Üeberblick, inwieweit der Entwurf von Bauwerken durch thermische Einflüsse beeinflußt wird. Es werden zunächst die Veränderungen der Baustoffeigenschaften unter erhöhten sowie tiefen Temperaturen beschrieben. Dann wird gezeigt, wie Zwängungskräfte aus thermischen Einwirkungen vermindert bzw. gänzlich vermieden oder durch entsprechende konstruktive Maßnahmen aufgenommen werden können.

1. GENERAL

In structures and structural elements thermal forces are resulting mainly from two reasons
- climatic conditions of the location of the structure and
- special thermal influences connected with its use.

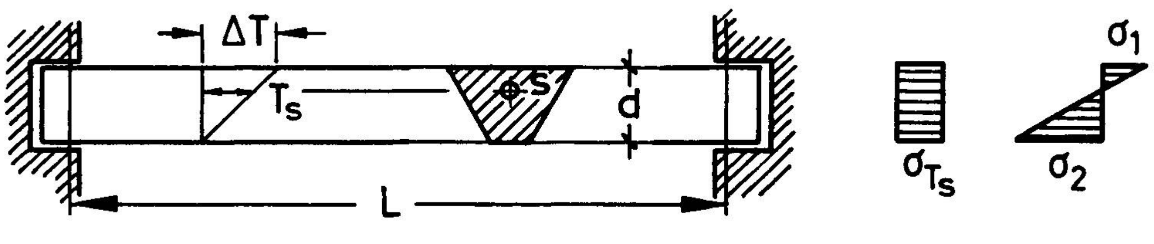
Extraordinary thermal conditions, as e.g. fire, need special considerations and measures.

Temperature changes in a structural element in relation to its initial temperature during construction either lead to deformations or to internal forces - if the thermal deformations are restrained. These internal forces are in equilibrium to the imposed thermal deformations, their magnitude thus depends on the resistance of the structure opposed to the deformations. This resistance is governed by the structural stiffness and the material properties of the whole involved structure. For concrete elements the stiffness depends among other things directly on the amount of external loads, the formation of cracks and time dependent effects, such as creep. By changing the stiffness of the members in a concrete structure the load depending internal forces may at least be redistributed, restraining forces in contrary are changed with respect to their amount.

For the estimation of thermal effects in structural elements it is suitable to pass over to the stresses hereby caused:

We differentiate between restraining and residual thermal stresses:

Restraining thermal stresses are caused by imposed deformations in the structure and occur only in statically undetermined systems (hyperstatic structures). They may be deduced directly from linear temperature changes. The sum of restraining stresses in each cross-section is generally different from zero; just as load stresses, restraining stresses may be summarized to internal forces (thermal load effects) and may be treated in design work equal to ordinary load effects (Figure 1a).



Equal temperature distribution over the whole length L, linear temperature gradient ΔT:

axis elongation $\Delta L \cong \alpha_T \cdot T_s \cdot L$, curvature $1/K = M/E \cdot J = (\alpha_T \Delta T)/d = \text{const}$

longitudinal restraint: $\sigma_{Ts} = \alpha_T \cdot T_s \cdot E$

flexural end-restraint: $\sigma_{1,2} = \pm\, \alpha_T \cdot \Delta T \cdot E \cdot J/d \cdot W_{1,2}$

rectangular cross-section: $\sigma_{1,2} = \pm\, 0.5 \cdot \alpha_T \cdot \Delta T \cdot E$

Fig. 1a Linear Temperature Strain Distribution and Restraining Thermal Stresses (Ideal Elastic Material)

Residual thermal stresses occur under non-linear temperature in the cross-section and are characterized by the fact that their sum in each section is zero. They may, however, cause deformations of the structure. In hyperstatic structures these deformations may lead to residual stresses and thermal load effects (Figure 1b).

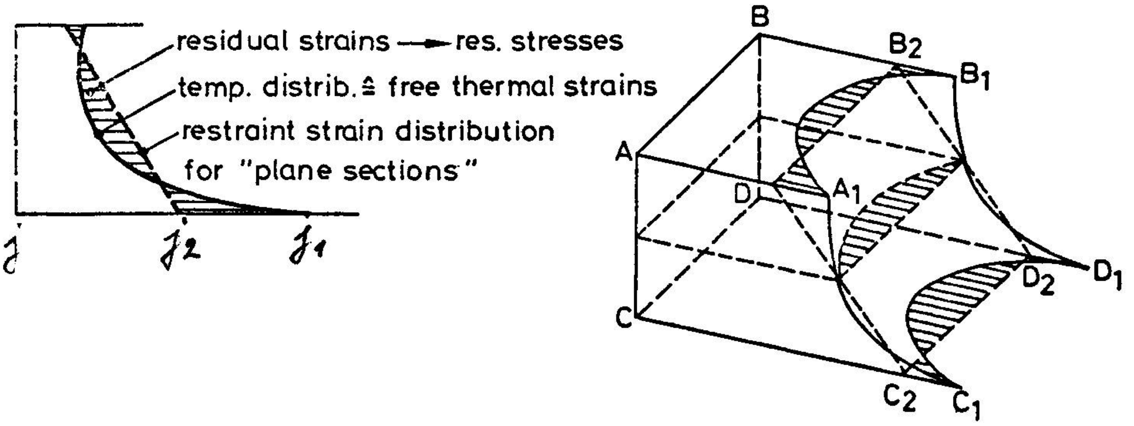


Fig. 1b Nonlinear Temperature Strain Distribution; Residual Thermal Stresses

The following table gives limiting values of temperatures; in general design is done according to these limiting values. For concrete structures the temperature in construction (column 3) corresponds approximately to the temperature of the fresh concrete, the rise of temperature by hydration is neglected. The temperature differences (column 4) refer to the surface temperatures of the unprotected structure [1, 2].

influence	region	temperature in construction	temperature differences under service conditions
1	2	3	4
environmental conditions	Central Europe	+ 15°C	± 30°C
	Polar Region	∿ 0°C	+ 15°C ≦ - 50°C
	Subtropical Regions/Tropics	+ 35°C	+ 35°C - 35°C
thermal effects by the use	up to		± 200°C
fire			≧ + 700°C

Table 1

2. INFLUENCE OF TEMPERATURE ON THE MATERIAL PROPERTIES

2.1 Steel

The change of the strength characteristics of usual steels under elevated temperature may be taken from Figure 2, 3 and 4. Figure 5 shows E-modulus and ultimate strain in failure vs. temperature of reinforcing steel.

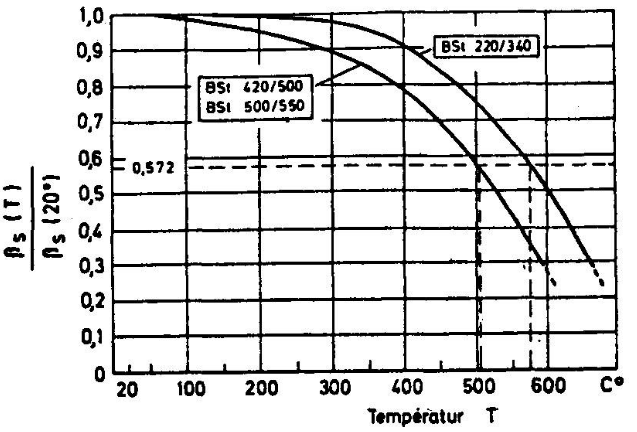


Fig. 2 Yield Stress of Ordinary Reinforcing Steel vs. Temperature

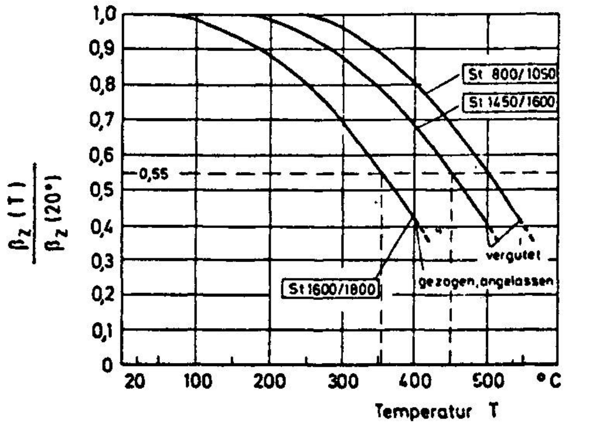


Fig. 3 Tension Strength of Prestressing Steel vs. Temperature

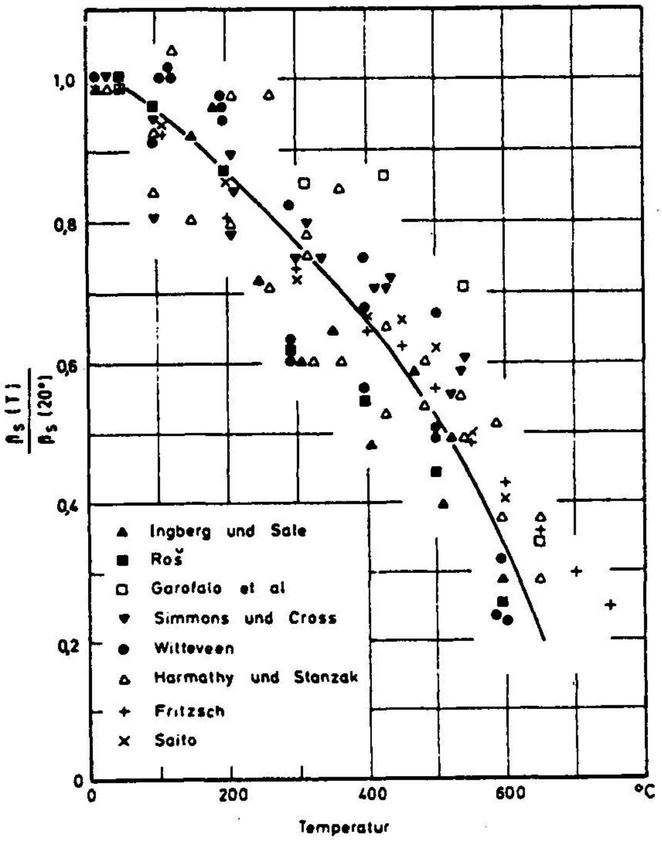


Fig. 4 Average Yield Stress of Structural Steel vs. Temperature

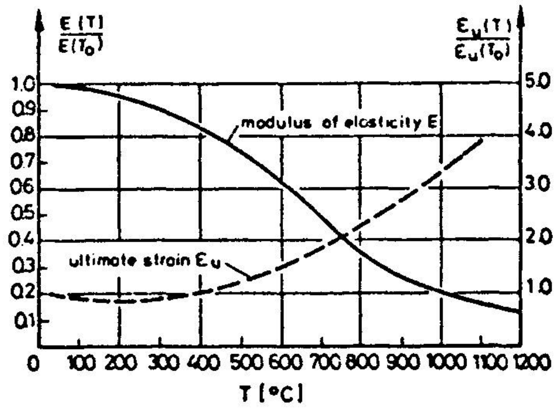


Fig. 5 Modulus of Elasticity and Ultimate Strain of Reinforcing Steel vs. Temperature

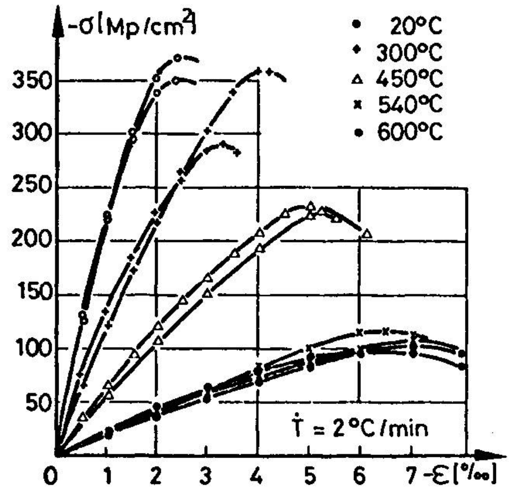


Fig. 6 Stress vs. Strain of Normal Concrete under Elevated Temperatures

If cold-deformed, respectively self-hardening steel is extremely heated, it shows different properties after cooling:

In case of slow cooling after heating of $\geq$ 400°C, self-hardening steel regains approximately its original material properties; a sudden cooling leads to embrittlement. Under certain conditions, cold-deformed steel does not or only partly regain its properties as a change in the texture may occur.

Under the influence of low temperatures (-180°C) ordinary steel becomes brittle, especially in the area of nicks. The material properties including the E-modulus increase slightly compared with the values under normal temperature, only the ultimate strain in failure decreases clearly [30, 31].

The thermal expansion of steel can be determined in a satisfactory way in the area of -200 up to +500°C with $\alpha_T = 10^{-5}$.

2.2 Concrete

The compressive strength of concrete decreases extremely under elevated temperatures; however, the loss of strength under unique heating is very low for temperatures $\leq$ +200°C, as it may happen under service conditions (Figure 6). Repeated heating on temperatures > 100°C leads even after 20 cycles to a significant loss of strength (> 20%), whereby simultaneous wetting and drying are acting critically [4]. The time dependent deformations (creep, relaxation) occur accelerated and enlarged compared with standard temperature [3, 4, 5]. Figure 7 shows exemplary the relaxation behaviour of concrete under heating with restrained elongation, Figure 8 shows the scatter band of the thermal expansion [5].

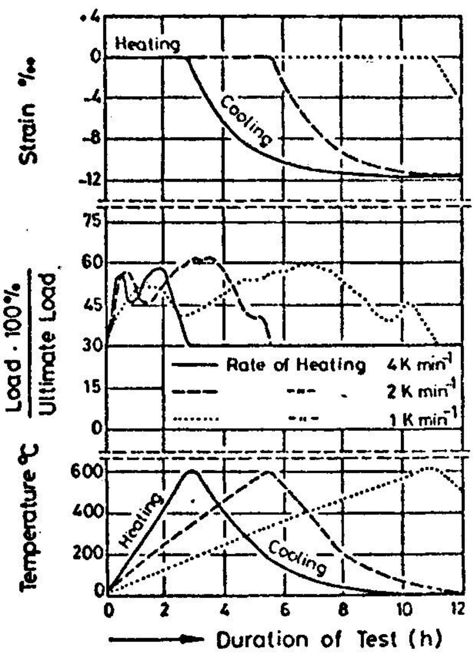


Fig. 7 Restraining Forces of Concrete Specimens with Longitudinal Restraint under Increasing Temperatures; Initial Loading 30% of Short-Time Strength

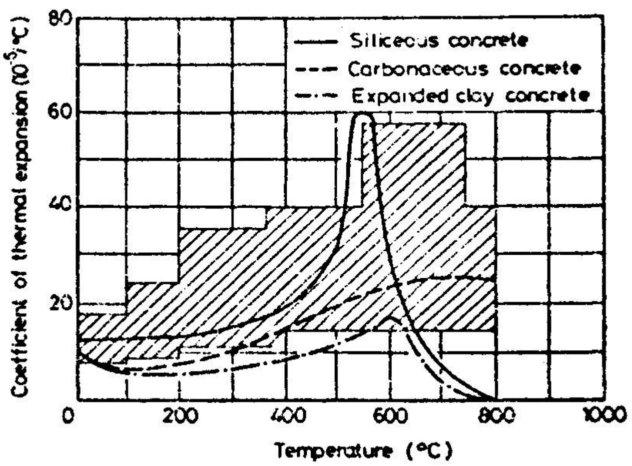


Fig. 8 Coefficient of Thermal Expansion of Concrete for Various Aggregates [3]

Concrete that is exposed to high temperatures for some time, especially > 100°C, drains progressively totally and therefore loses its active protection against steel corrosion [6, 7].

Figure 9 shows the stress-strain relation of concrete (at ambient temperature and at -170°C) that was stored in water respectively under standard climate 20/65 conditions until testing after approximately 90 days. It shows that the compressive strength and the E-modulus increase depending on the state of humidity under low temperatures. Concrete saturated with water reaches with low temperature a comparatively still higher compressive strength; however, a high moisture content of the concrete causes with cyclic freezing and thawing a significant loss of strength (Figure 10).

Figure 11 shows comparatively the thermal strain of prestressing steel, normally stored concrete and water saturated concrete. Under cooling cycles prestressing steel as well as reinforcing steel and normally stored concrete show quite linear shortening, but steel shows obviously the higher deformations under the same temperature decrease. In reinforced structural members therefore "self-stressing" occurs. Water saturated concrete reacts in cooling down cycles significant according to the properties of ice [8, 9].

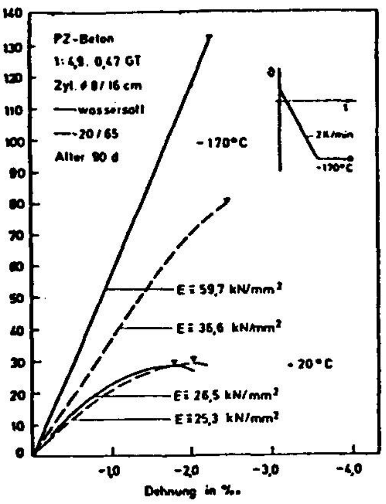


Fig. 9 Stress vs. Strain of Concrete under +20°C and -170°C; Water Saturated and Normally Restored

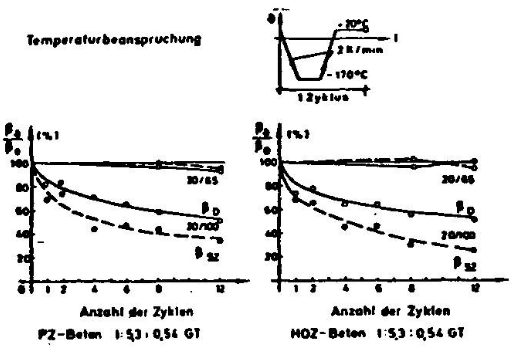


Fig. 10 Influence of Humidity on Residual Strength of Concrete after Cyclic Low-Temperature Treatments

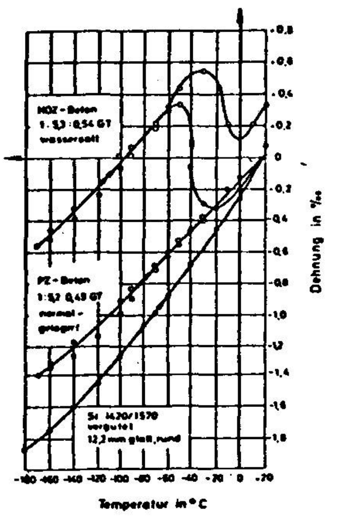


Fig. 11 Strain vs. Temperature of Water Saturated and Normally Stored Concrete and Prestressing Steel

3. RECOMMENDATIONS FOR CONSTRUCTION UNDER EXTREME AMBIENT TEMPERATURES

3.1 Steel Structures

Erecting of steel structures is in a wide range independent of the ambient temperature conditions. This is especially valid for the "hot countries". Temperatures lower than approximately +5°C may in contrary lead to embrittlement of steel and require some additional caution measures: Prestressing should not be done with temperatures below 0°C, unloading and handling of steel members must be done carefully in order to avoid cracks or brittle failure, welding may also lead to difficulties and bad results.

3.2 Concreting with Cold Weather

With cold weather the fresh concrete has to be placed at a minimum temperature of $\geqq$ 5°C due to the delay of hardening and the possibility of lasting influence on the concrete properties. If the air temperature decreases below -3°C a temperature of > 10°C has to be aspired by physical measures for the fresh concrete [10].

3.3 Concreting with High External Temperatures

Temperatures of more than 30°C of the fresh concrete can lead to loss of strength of the hardened concrete; usually a temperature of $\leqq$ 30°C is required for the fresh mixed concrete. The observance of this temperature limit is in subtropical and tropical countries not possible without additional measures [2, 10]. Some of these measures are:
- white paintings for cement bunkers and vehicles for ready mixed concrete
- spraying the gravel and sand boxes with water; the cold due to evaporation reduces the temperature of the fresh concrete for 2 - 3°C

- cooling of the mixing water, addition of ice.

Another danger for the hardened concrete is extreme sunlight, hot wind and low humidity of the air; the concrete has to be protected against fast drying; sufficient supply with humidity has to be guaranteed (curing).

3.4 Plastics

For the hardning of plastics, e.g. artificial resin adhesives, the temperature of the structure and the external temperature are of importance as is known; although the temperature of the structure is often higher than the atmospheric temperature in the northern regions occur temperatures of the structure of less than 5°C, so that a satisfying hardening process of the artificial resin can not be expected. In this case it is also not sufficient to mix the adhesive under increased temperature - e.g. in a heated room - as the adhesive adopts after application immediately the temperature of the structural element. In the last time special methods were successfully applied: The joints of segmental bridge girders were warmed up with heating wires placed in the glue. By this it was possible to extend the period of construction in spite of the cold weather and to limit the hardening process of the resin on a practicable time [11].

Resin mortars and similar materials as used e.g. for glueing segmental prestressed girders show accelerated hardening process under high ambient temperatures. This phenomenon has to be taken into account because of its influence on the time of workability of the mortar in hot countries.

4. DESIGN FOR THERMAL LOAD EFFECTS FROM ENVIRONMENTAL CONDITIONS

4.1 Steel Structures

In general temperature dependent stresses in steel structures have to be considered for the analysis under service conditions. Whether and to what extent imposed deformations and thermal load effects may be neglected in a (plastic) ultimate limit state design depends from the kind of the structure and its load bearing behaviour. The neglection of thermal load effects in structural elements being mainly stressed by compression is not in principle permitted [12, 13].

For composite steel structures the different thermal conductivity of steel and concrete has to be considered; for composite steel bridges e.g. it is usual to treat the following thermal load cases:
- constant change of temperature in the whole bridge cross-section
- linear temperature gradient over the whole cross-section (surface of the bridge deck warmer than bottom flange)
- temperature difference between concrete bridge deck and the steel structure.

4.2 Concrete Structures

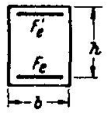
Check Under Service Conditions:
If the thermal conditions influence the state of stress in a hyperstatic structure in an unfavourable sense, then the maximum values of the thermal load effects have to be considered. These effects have to be calculated using stiffness values on the safe side. With structural elements under bending with and without tensile forces the decrease of stiffness due to cracking may be considered (see the following table) [14, 15].

If on the other hand the state of stress is influenced by the thermal conditions in a favourable way, thermal effects may generally be neglected, as for the behaviour of the corresponding structural elements the load condition "external load without simultaneous temperature influence" is relevant.

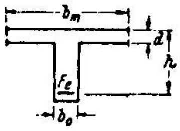
With reinforced concrete or prestressed concrete structural elements being subjected to certain thermal effects for a long time it is generally useful to consider the favourable influence of creep. However, it must be considered that the decisive load conditions often already coincide with the origin of thermal effects and therefore the decay due to creep does not become relevant.

The following table gives upper boundary values for the real flexural stiffness of reinforced concrete structural elements in dependence of normal force and degree of reinforcement:

steel quality	axial force n	percentage of reinforcement μ[%]	$\chi = \frac{K_B}{E_b J}$
BSt220/340	all n	all μ	1.0
BSt420/500 BSt500/550	$n<-0.15$	all μ	1.0
	$\lvert n\rvert \leq 0.15$	$\mu \leq 0.6$	1.0
		$\mu > 0.6$	0.65
	$n>+0.15$	all μ	$0.2+6(\mu+\mu')$



$n = \frac{N}{bh\beta_R}$; $\mu = \frac{F_e}{bh}$; $\mu' = \frac{F_e'}{bh}$



$n = \frac{N}{b_i h\beta_R}$; $\mu = \frac{F_e}{b_0 h}$; $\mu' = \frac{F_e'}{b_0 h}$

$b_i = b_m \frac{d}{h} + b_0 \left(1 - \frac{d}{h}\right)$

Table 2 Effective Stiffness in Bending K_B of Reinforced Concrete Structural Members depending on the Actual Axial Force and the Percentage of Reinforcement μ

Design procedure:
In general an ultimate state design is required; therefore the relevant load effects are determined according to equation (1):

$$N_U = \nu_Q \cdot N_Q + \nu_{th} \cdot N_{th} \tag{1}$$

For reinforced concrete structural elements in bending, the safety factor ν_{th} for thermal load effects may be assumed as 1.0, as with increasing loads and deformability of the structure the thermal load effects - depending on imposed deformations - decrease. With structural elements being mainly stressed in compression a significant decrease of restraining forces near the ultimate state of stress does not have to be expected; therefore in these cases equation (1) should be verified with $\nu_{th} \cong 1.5$.

However, in addition the total state of stress under service conditions should be examined using the values of table 2 in order to avoid unjustifiable crack formations, according to equation (2):

$$N = N_Q + N_{th} \tag{2}$$

5. INFLUENCE OF THERMAL LOADS ON THE STRUCTURAL FORM

5.1 General Remarks

Structural elements being subjected to extreme and significantly changing temperatures must be free to deform or able to accommodate the imposed deformations. The formation of cracks due to thermal effects under service conditions may be accepted for reinforced concrete structural elements only in exceptional cases when cracks are neither for the load bearing capacity nor for the function of the structure of importance. Therefore in most cases it is necessary to retain the uncracked state. In hot countries the fluctuations of the external temperature due to the day/night cycle are very serious; in general the temperature gradients caused hereby in walls and roof structures have to be considered taking into account big temperature differences: The surface temperature may reach 70°C and more under intensive exposure to sunlight in subtropical areas, whereas the temperatures during the nights may reach more than 30°C lower. The deformations and thermal load effects in the structural elements reach three- up to fourfold values compared with the conditions in Central Europe; so the thermal effects exceed by far all ordinary load effects [2, 29].

Additional difficulties occur if the structure is not only subjected to such extreme climatic conditions but also has to take up hot liquids. With concrete structures the problem to guarantee no cracks becomes special importance. Especially in such cases thermal load effects have to be avoided if possible; a sufficient number of contraction joints in connection with statically determined structures can mostly be successful. The price of such a structure was often found smaller than with a jointless structure and perfect consideration of the thermal loads [2].

5.2 Joints

Structural elements between expansion joints shall be able to move uniformly to all sides, if possible; stiffening components as staircases or elevator shafts therefore should be arranged in the middle between two joints respectively between joint and end of the structure. Joint spacing a and gap of the joint b have to harmonize with the expected motions of the structure and the restraining forces as e.g. friction on the soil or stiffness respectively deformability of the relevant structural elements. As far as risk of fire has to be considered, the gap of the joint b should be chosen as

$$b = a/800 \quad \text{up to} \quad b = a/600$$

Joint spacings in buildings of more than 40.0 m require in general special investigation [10, 16].

Designing of expansion joints in structures under fire protection aspects has to consider that even after a long period of usage of the structure unrestricted possibility of motion must exist in case of fire, but the passage of fire or hot gases through the joint must absolutely be avoided. In this connection it must be taken into account that maintenance work on expansion joints is mostly omitted, in some cases even impossible. The penetration of dust or other particles must be avoided and aging of the filling and covering materials of the joints should not limit their function even under permanent stressing by movements of the building [15, 16, 17].

Figure 12 shows a joint designed under fire protection aspects.

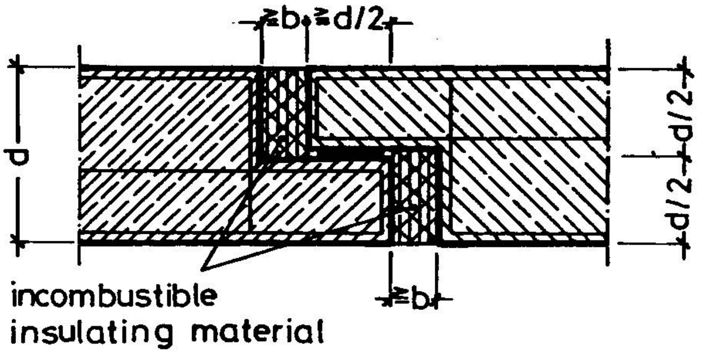


Fig. 12 Proposal for the Design of an Expansion Joint with High Fire Resistance Properties

5.3 Design Considerations

If it is not possible to avoid imposed deformations by thermal effects, e.g. if joints and in consequence differential settlements can not be accepted, a very careful coordination of the over-all design has to be executed with the aim to reach an optimization of the dimensions of the structural elements (e.g. wall and roof thickness) with respect to thermal load effects, shrinkage etc. and ordinary load effects.

It is often favourable to avoid influences of great temperature differences by means of efficient insulation measures; as far as the local conditions allow it, the possibility of an external covering with earth should be taken into account; this is probably the cheapest solution.

The use of prefabricated structural elements offers several advantages to avoid thermal load effects. As far as reinforced concrete structural elements are concerned the curing can be executed precisely at the manufacturing plant, whereby also undesired shrinkage effects can be excluded. Suitable supports can guarantee the flexibility of each structural element under temperature changes and thus prevent thermal load effects.

With steel structures in buildings or other engineering structures the protective effect of insulations is looked for; however, the remaining temperature elongations can mostly be absorbed by the whole load bearing structure. Movable supports, slotted hole connections etc. are hardly no more produced [13].

An exceptional case should here be pointed out, which is characteristic for the additional difficulties in hot countries: Overflow pipes made of reinforced concrete are normally not coated inside in moderate climate. In the Orient, however, where the sewage temperature is relatively high and wash water has to be economized due to water shortage, such a coating is necessary - mostly on the basis of tar-epoxy resins - as the microbes producing aggressive acid multiply best at water temperatures of +30°C [2].

The architectural design can also be useful with respect to a reduction of difficulties raised by temperatures:

Ventilated roof structures produce a clear improvement of the ambient temperature inside the building without expensive air conditioning installations, especially if the roof structure is projecting over the facade, giving shadow. Furtheron a shadowy covering of the external facade - e.g. with a prefabricated concrete network being nevertheless light-transmissive - will in many cases be just as much of advantage. It must be pointed out that these basic ideas can even be found from ancient times in the original typical buildings in subtropical and tropical zones.

6. EXAMPLES FOR STRUCTURAL DESIGN

The selection of the structural form of any building with respect to thermal forces is connected in a very sensitive way with the basic assumptions for its design and verification. More difficulties in this respect arise with concrete structures; therefore two examples taken from this field of application shall finalize this report, giving perhaps some practical recommendations!

6.1 Design of a Silo for Thermal Load Effects

Silos for cement clinker have to be designed not only for the usual loads (dead load, wind, pressure of the filling material etc.) but also for thermal load effects. The medium filling temperature of the clinker is ranging between 100°C and 200°C depending on temperature fluctuations during process of the production of clinkers. The actual clinker temperature depends besides others primarily on type and efficiency of the cooling system being subsequently added to the furnace and length of transportation distance to the feed opening. The hot clinker transfers part of its heat on the air inside the silo and part on the structural elements of the silo by means of conduction, convection and thermal radiation.

In the area below the level of the filling material the silo wall is being heated through the direct contact to the clinker (heat conduction). Above the filling material the heat flow consists on the one hand of a convective part, whereby the clinker transfers the heat by the air on wall and roof of the silo; on the other hand the heat flow results from the radiation of the clinker.

It is obvious that the maximum temperature gradient in the silo wall adjusts above the level of the filling material, resulting from radiation and convection. The air temperature above the filling material increases with rising level of the filling material and consequently the temperature gradient in the silo wall increases.

Below the level of the filling material the temperature gradient in the silo wall produced by direct contact with the filling material decreases quickly through a nonsteady heat conduction, whereby the cooled filling material next to the silo wall acts as an insolation to the more heated cement clinker inside.

In principle, the temperature conditions for the area above and below the level of filling material can be approached by a heat balance calculation [18, 19, 20, 21]. But this is often too difficult. For the designing procedure some recommendations for approximate temperature distributions are needed. Figure 13 and 14 show datas gained theoretically but examined by measurements in a clinker silo, which can be taken as basis for further calculations [21, 22]. In the area below the level of the filling material it may be assumed a linear decrease of the temperature gradient and of the temperature in the middle plane of the wall up to the bottom of the silo.

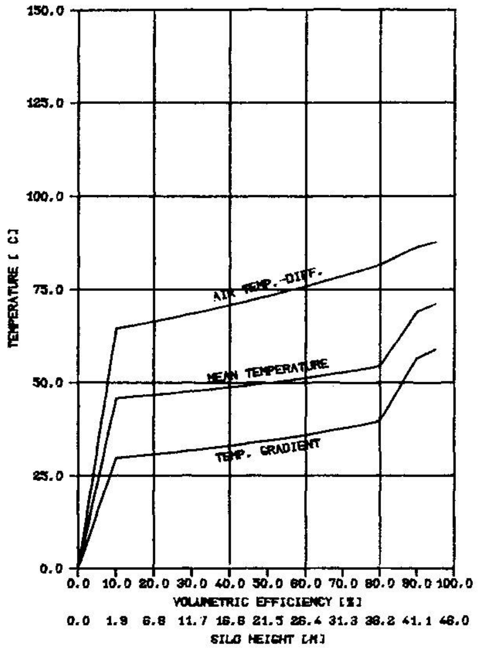
6.2 Design of LNG-Tanks with Respect to Cracking

The design of LNG-tanks is significantly influenced through the special importance of the thermal load case. Under service conditions the thermal load is being kept low by means of suitable insolations and operation devices. In case of a catastrophe one has to rely on the fact that by sufficient reinforcement progress of cracks and crack-width remains restricted with respect to three requirements:

- "Through-and-through cracks" may never penetrate the cross-section of the wall in order to avoid leakage of the tank.
- Although there are no signs that LNG endangers the prestressing steel by corrosion and although even under sudden cooling and impact loading the properties of the steel do not become unfavourable, immediate contact of the LNG to the prestressing steel should be avoided.
- A thermal loading by a cold wave, including a liquid impulse, must not lead

Quantitiy of Filling: 80.0 [m^3/h]
Dedusting: 10000.0 [m^3/h]

Filling Temperature: 175.0 [C]
Free-Air Temp.: 20.0 [C]



Quantity of Filling: 80.0 [m^3/h]
Dedusting: 10000.0 [m^3/h]

Filling Temperature: 175.0 [C]
Free-Air Temp.: 10.0 [C]

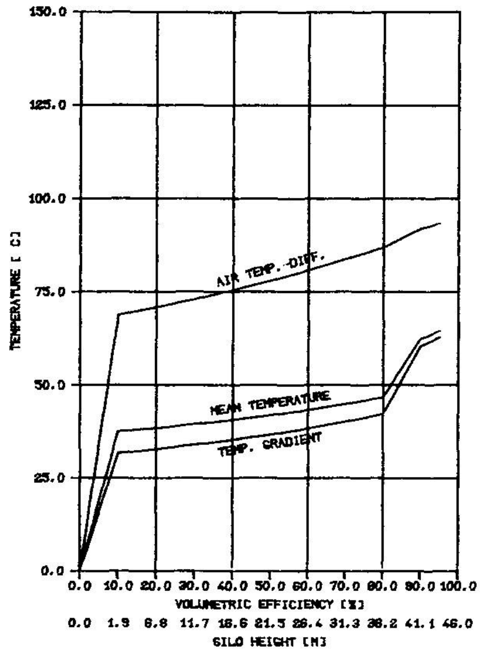


Fig. 13, 14 Temperature Distributions vs. Level of Hot Filling Good

to a brittle failure and all cracks should close again; therefore the prestressed and passive reinforcement as well must not exceed also in these cases the elastic portion.

Some aspects concerning the crack behaviour and the influence of very low temperatures are being discussed in the following:

The different coefficients of thermal contraction of steel and concrete were already pointed out. With usual material pairing theoretical thermal residual stresses in the range of 80 up to 150 N/mm^2, possibly higher, occur in the steel under -170°C compared with the temperature of 20°C [23]. This is about 10% of the yield stress of prestressing wires, which increases itself for 15 ... 25%. This self-prestressing effect, however, charges the bond. Furtheron it should be examined, whether instead of the load case "prestressing" before creep and shrinkage the minimum filling level in the LNG-tank under low temperature becomes the critical load condition for the concrete compression zone in the wall (including the thermal pressure stresses acting synonymously with the prestressing forces) [24].

The required prestressing forces rise progressively with the required minimum thickness x of the concrete compression zone; a remaining compression zone under bending and tension even under extraordinary conditions is essential in order to avoid leakage of the tank. Sometimes it is requested that the cracks may not reach the prestressing steel, that means $x \leq 0.5$ h (e.g. with centric tendons). The prestressing force F_T, being necessary in addition to the hydrostatic conditioned prestressing force F_N to guarantee a sufficient hight of the compression zone is estimated between F_T = 0.6 MN/m^2 for x = 0.3 h and F_T = 2.8 MN/m^2 for x = 0.5 h [25, 26]. An increase of prestressing seems to be more economic than an enlargement of the passive reinforcement in this respect.

Ordinary reinforcing steel may not be used as passive reinforcement for LNG-tanks; steel with high yield strength up to 1500 N/mm^2, e.g. heat-treated, ribbed wires with diameters 10 up to 16 mm, is recommended. Its design stress should not exceed 500 N/mm^2 under normal temperature respectively ∿ 70% of the yield stress under low temperature [27].

In most cases steel of this kind shows clearly smaller "related rib areas", which may produce difficulties for the bond behaviour. In addition bond increases under low temperature less than the compressive strength of concrete and is synonymously preoccupied by the self-stressing effects, therefore crack distance and crack-width are expected to be greater under low temperature than estimated under standard temperature values [23].

In connection with the problem of bursting of an inner LNG-tank by a brittle failure the question of crack propagation in prestressed tank walls occurs. For prestressed concrete such a "zipping open"-effect can be excluded if the remaining prestress after fracture of one tendon is still able to avoid an advance of the crack; that means the neighbouring tendons must be able to take up the load of the broken one by bond and to carry it within reasonable limits and reconcile the crack [28]. Sufficient passive reinforcement in good bond and tendons in not too far distance are therefore necessary conditions for suitable behaviour of the structure even under extraordinary conditions.

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