Summary

1. Introduction

Plain or steel fibre concrete slabs on building ground with and without reinforcing steel armouring under load and restraint deformation were examined. Normally there is no risk of structural collapse –the limit state of serviceably is more imporant than the ultimate limit state.

2. Basis Investigation

On the basis of intensive enquiries of previous works (reports, papers, dissertations), by own attempts and extensive parameter studies an own design method was developed:

- interaction between building ground and base plate: the bedding module was determined from settlement calculations with given deformation modulus E_{v2} of the building ground.
- properties of material: the design assumption of the flexural strength by MC 90 was extended for the case of eccentric tension. On the bases of executed structural member attempts for steel fibre concrete and plain concrete a higher fatigue strength steel fibre concrete was determined. The inconsistency of the damage hypothesis after Miner - Palmgren and the '4. Potenzregel' ('4. Power rule') was shown.
- for traffic loads with air tyre a load distribution area dependent on the load height was taken into account. Both the statistical distribution of the load height and the lateral distribution over the lane were determined. For the load cases in the slab center, slab edge and slab corner the loads from single wheel, axle load, tandem and three-axle load were included.
- concerning the temperature: the average yearly and daily temperature for industrial halls (using the basis recording to iBMB) and outdoor areas (according to DIN 4710 considering the incoming and outgoing warmth) were taken into account. The transient temperature distribution over the cross section for different typical days on january (representing winter), july (summer) and april (spring/autumn) was calculated using ANSYS considering a varying coefficient due to wind influence. The temperature distribution for the winter mentioned in the DAfStb guideline 'Betonbau beim Umgang mit wassergefährdenden Stoffen (' concrete building while handling water-endangering materials') is too extreme and should be corrected. Non-constant temperature distributions were determined as stamped initial condition by calculation of the zero-stress temperature from drain of heat through hydration with the hydration degree (alpha) considering relaxation, available ambient temperature as well as wet subsequent treatment. The dispersion of the temperature from the material indices and the different diurnal variations is indicated.
- the time depended course of shrinking according to MC 90 with the inclusion of relaxation was approximated and formulated as a non-linear distribution over the section depth.

3. Finite Element - Model for Calculation

- by using the program ANSYS a finite element - model for calculation was set up. The boundary and intermediate conditions can be considered such as continuous slab, transverse and longitudinal joints with dowels / anchors, assumption of a base course (road base) with full or sliding bond to the slab as well as the vertical and horizontal interaction between slab and building ground. Action effects from temperature, shrinking, self weight and live loads

(traffic loads) are settable. The calculations can be executed "statically" with fixed characteristic values or "probabilistically" by assumption of the input characteristics from geometry, action effects and material parameters as basics variable with statistical distribution functions and application of the Monte Carlo simulation method.

4. Results

The most relevant results of the executed calculations were

- interaction between slab and building ground: on the basis of the executed calculations a base course can be replaced by a increased bedding value k_s. An optimization of the base course thickness and the slab thickness with variation of the stiffness (elastic and deformation modulus) was given.
- load: On the basis of Márkus / Bercea an own realistic approximation assumption for the calculation of a centric surface load (wheel load) was set up. By means of a diagram the stress can be pursued with variation of the parameters load height, load distribution area, elastic module, bedding module, cross-sectional height. Calculation aids for single wheel, axle load are specified with different load cases.
- temperature: For the case of a constant temperature changes an analytic derivation of the parts free deformation, flexible deformation and restraint were indicated. The influence of the friction and the temperature size on the stresses was examined. For the case of the temperature gradient the effect of a positive or negative temperature curvature was observed. The statements of *Eisenmann* according the determination of the border length by single slabs were limited or corrected; the postulated maximum stress as 1.2 times of the stress from temperature gradient by long slabs applies only in the theoretical case of the rigid support; with the bedding support the maximum stress is smaller than 10 %. For "real" temperature distributions the results of the parameter studies under variation of the temperature distribution, width, length, thickness, the bedding module and the elastic module was arranged.
- shrinking: The stress at different times and for different systems were determined. In case of none permanent drying of outdoor slabs the influence of shrinking is small. Shrinking of indoor slabs leads to an increase of cracks deformation within the surface area.
- Combination of load and restraint deformation: A superposition while using short slabs is in general and while using long slabs in the boundary regions illegal. From the probabilistic calculations the safety for different systems was determined. A life prognosis for concrete roads with consideration of the daily temporal and seasonal fluctuation of the temperature and the vehicle traffic as well as the prognosticated increase of traffic in the coming years was set up.
- reinforced slabs: The crack width limitation according to EC 2 (DIN 1045 07/88) and MC 90 (DIN 1045 07/01) was extended on steel fibre concrete and verified on the basis of executed attempts. A minimum aspect ratio of reinforcement is recommended. Calculation diagrams were set up for single- and two-layer reinforcement.

5. Summary

With this work plain or steel fibre concrete slabs on ground with or without a reinforcing steel armouring can be calculated and designed realistically.