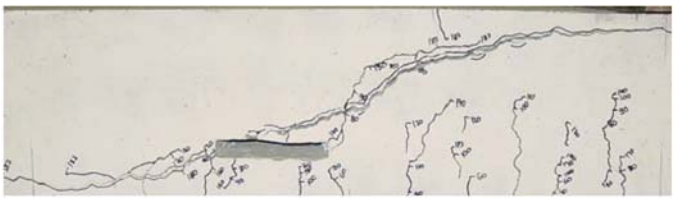
# Application limits for concrete slabs without shear reinforcement with integrated ducts vertical to the load-bearing direction

For the vertical load carrying capacity of concrete slabs without shear reinforcement with integrated ducts so far no calculation concept was present. A research project was financially sponsored by the German Concrete and Civil Engineering Association (DBV) and the German Institute for Civil Engineering (DIBt).

More and more the framing systems for general and industrial buildings will be claimed for HVAC- and sanitary installations. During the daily construction practice the load-bearing capacity reduced by embedded pipes and/or ducts will be roughly estimated. In case of not observing the reduction of load carrying capacity there could be security lacks.



Picture 1-1: break pattern of a test specimen

The following objectives have been defined for the research project:

- Definition and description of the vertical load capacity of slabs with integrated ducts without vertical reinforcement.
- Definition of limit of applicability with determination of minimal distances.

Thereby the following parameters were attended:

- Height of the opening in the test specimen,
- Proportion of opening height (in case of rectangular openings) or opening diameter (in case of circular openings) to the structural depth,
- Position of the opening in longitudinal direction,
- Influence of an additional loading with centrical tension load,
- Groups of openings,
- Openings in point of zero moment.

Results

The German standard DIN 1045-1:2001-07 gives a design equation (Gl. 70) fort he vertical load carrying capacity without shear reinforcement $V_{Rd,ct}$ .This equation should be expanding with a factor considering the openings.

The following design equation for members with circular openings with proportion of opening diameter and structural depth between 0,2 and 0,5 was found:

$$V_{Rd,ct,red} = k \cdot V_{Rd,ct} \quad \text{with:} \quad k = k_{Ø} = 1 - \frac{d_{Ø}}{d} \quad \text{for circular openings}$$

$$k = k_{\square} = 0{,}95 - \frac{d_0}{d} - (\frac{d_0}{d} - 0{,}03) \cdot \ln(\frac{b_0}{d_0})$$

$$\text{for rectangular openings} \quad 1 \le \frac{b_0}{d_0} \le 5$$

$d_{Ø}$ : diameter of circular openings
$d$ : structural depth
$d_o$ : height of rectangular openings
$b_o$ : width of rectangular openings

Limits

1. Circular openings positioned between the middle axis and the pressured side of the concrete Member the factor $k_{\varnothing}$ could be increased by 0,1.
2. In case of positioning lots of openings the axis distance between the openings should be more than three times the opening diameter.
3. The load reduction in zones were punching is decisive is open. In the moment it could be only advised to conserve these areas.
4. Basically openings must be considered in case of bending design. For example the openings could reduce the pressure zone in the concrete member.