Structural Assessment of Existing Road Bridges in the German Federal Road Network

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Existing Structures

- Bridges: 39,414
- Entire Bridge Deck Area: 30.6 Mio. m²
- Entire Length 2,125 km ~ 1,320 miles
- Most are between 40 and 60 years old
- 87% are made of Concrete (Fig. 1)

Challenges

Steadily increasing traffic loads (Fig. 2) and simultaneous ageing of structures lead to a reassessment of the load bearing capacity.

The large number of structures makes a prioritization necessary. For this, a prioritization process was developed.

The recalculation of concrete road bridges frequently yields calculative load bearing capacity deficits (for prestressed concrete bridges especially in the case of shear capacity). Therefore, new design approaches are being developed in various research projects and published in the Structural Assessment Guideline.

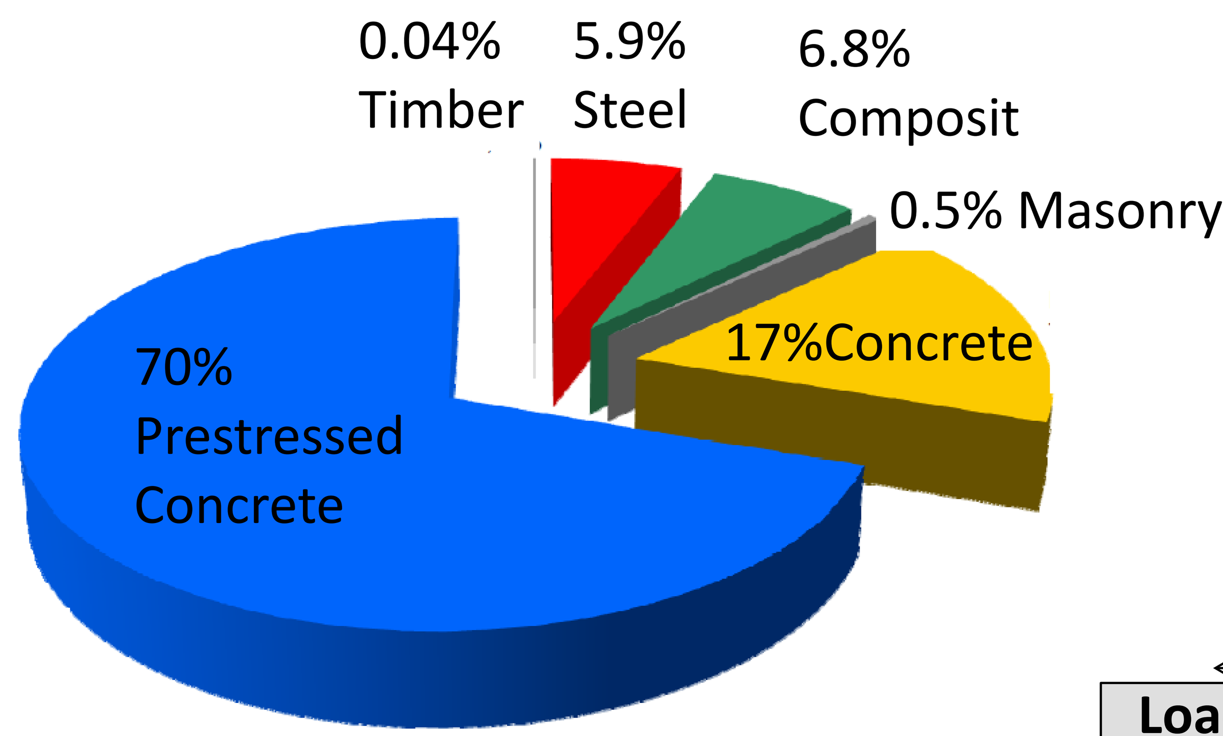
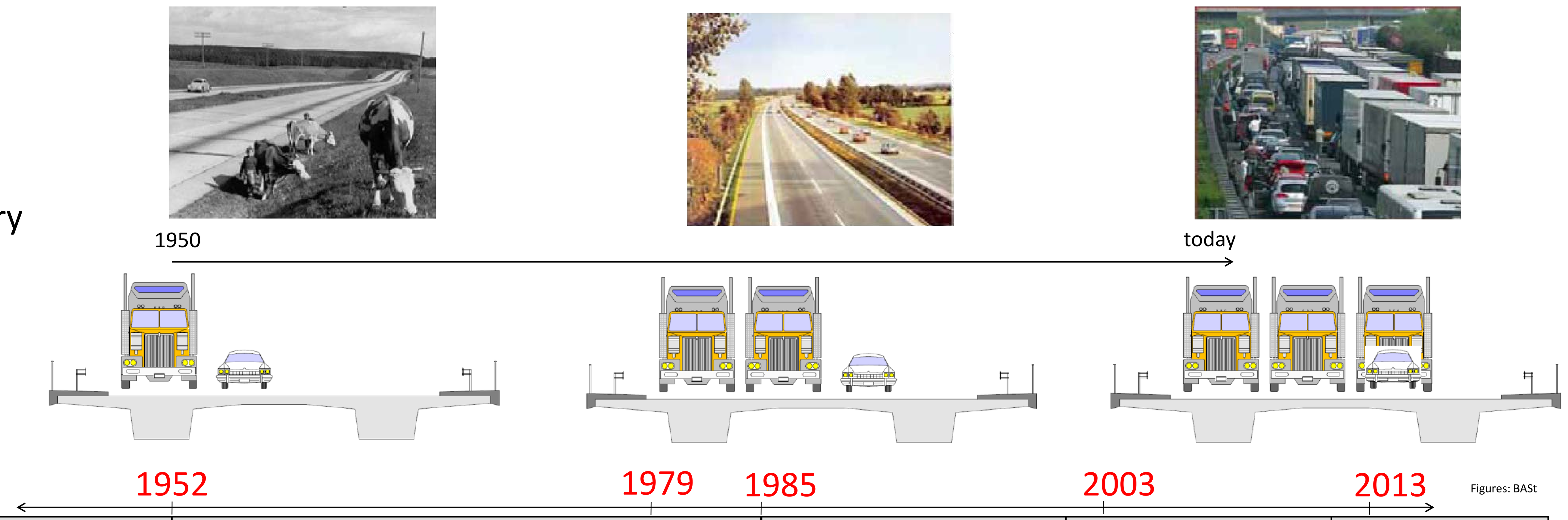


Fig. 1: Bridge Statistics – Building Materials [1]



Load Model	BK 60	BK 60/30	LM 1 (DIN FB)	LM 1 (EC)
Single Loads	60 to	60 to/30 to	similar to 60/30	60 to/40 to/20 to

Temp. grad.	ΔT_M was not considered	ΔT_M taken into account since 1979

Fig. 2: Development of the Actions for Design and Detailing Road Bridges

Prioritization Process

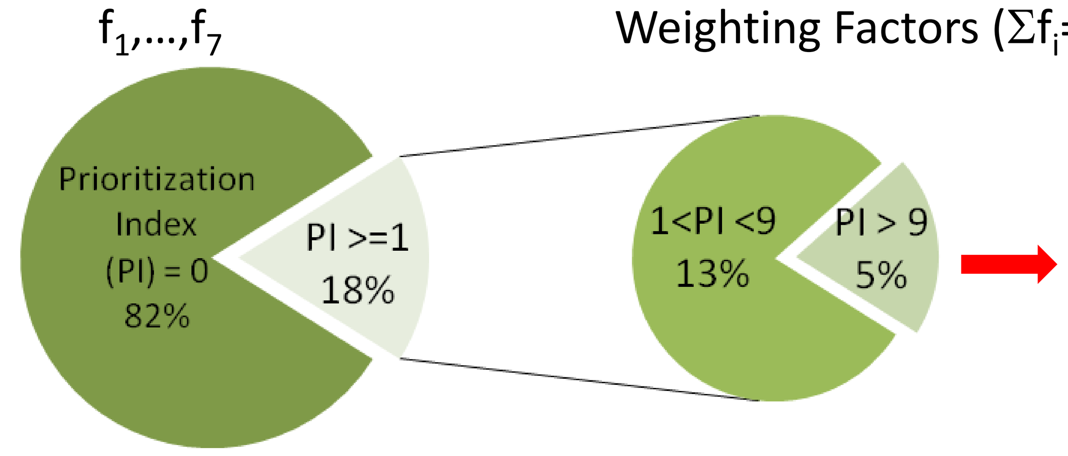
- A prioritization index has been developed
- Known design deficits in the are taken into account by numerical values
- The prioritization index results from the sum of all individual values
- The road administrations are asked to recalculate the identified bridges (Fig. 3)

Structural Assessment Guideline (SAG)

- The SAG (Fig. 4) was first introduced in 2011
- Takes into account the characteristics of existing structures (old materials, former design an detailing concepts)
- Provides a step-by-step approach with increasing effort (Level 1 to Level 4)
- Is constantly being evolved and updated

$$Z_{BAST} = f_1{*}Z_V + f_2{*}Z_{ZN(\ddot{U}B)} + f_3{*}Z_{\Delta T} + f_4{*}Z_{KF} + f_5{*}Z_Q + f_6{*}Z_{SpRK} + f_7{*}Z_{ZN(TBw)}$$

Z_{BAST}	Prioritization Index
Z_i	Rating Values between 0 … 4 (0 … 5)
	for: Traffic, Bridge Condition, ΔT-Consideration, Coupling Joints, Shear Design, Stress Corrosion
$f_1,…,f_7$	Weighting Factors (Σf_i=7)



~5% of the existing Bridges have to be assessed urgently.

These 5% represent 25% of the total Bridge Deck Area.

Fig. 3: Prioritization Process – Approach and Results [2]

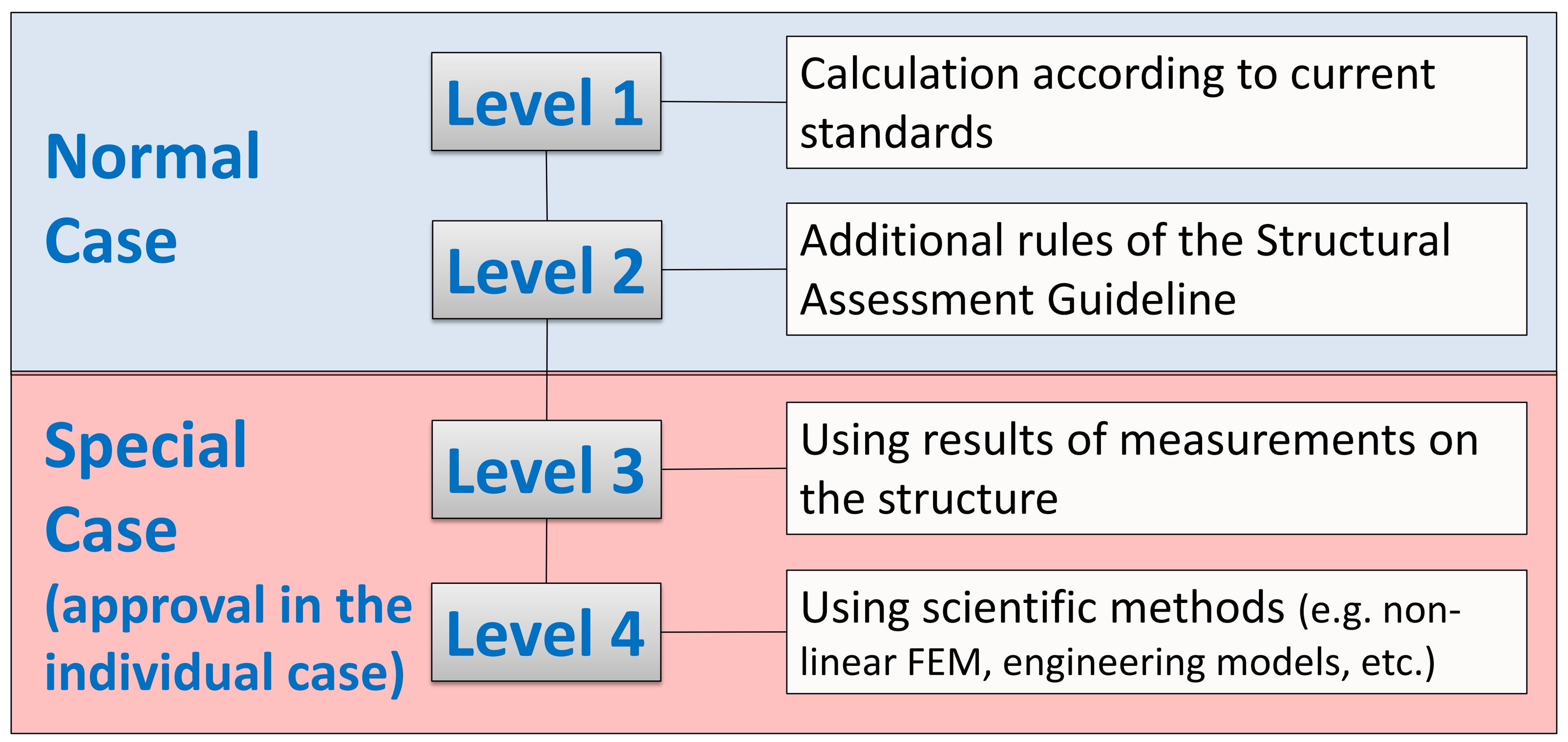


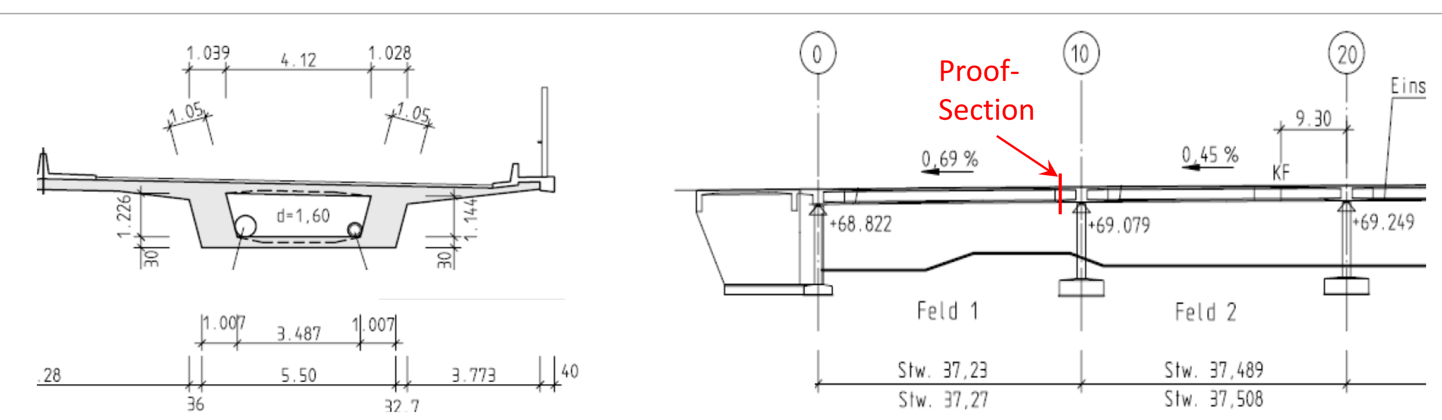
Fig. 4: Structure of the Structural Assessment Guideline [3]

Assessment Results

- Most calculations according current standards lead to significant load bearing capacity deficits (Fig. 5)
- Reasons besides the increased traffic are modified rules for design and detailing
- Current standards do not cover the boundary conditions of old bridges (e.g. materials, types of stirrup reinforcement, etc.)
- In determining the shear resistance of prestressed concrete bridges, the most relevant calculative deficits are found

Development of Scientific Approaches

- In various research projects the shear capacity of old prestressed bridges is investigated (e.g. Fig. 6)
- The new approaches are applied as part of SAG Level 4
- The Level 4 approaches are the basis for the further development of the standard proofs of Level 2



Cross Section in distance d from intermediate support								
LoA	Level 1	Level 2	Level 4					
Assessment Basis	DIN FB 102	DIN FB 102 + SAG	Approach by GÖRTZ [4]		Arch Action Model [5]		Modified Principal Stress Model [4]	
Load Model	LM 1							
Partial Factor Self-Weight	1.35	1.2						
Strengthening-Measure	-	-	-	external Tendons	-	external Tendons	-	external Tendons
Check fulfilled?	NO	NO	NO	NO	NO	YES	NO	YES
Utilisation factor	2.37	2.01	1.22	1.15	1.24	<1.0	1.53	1.05

Fig. 5: Assessment Results for Shear Resistance Level 1, 2, 4 [4]

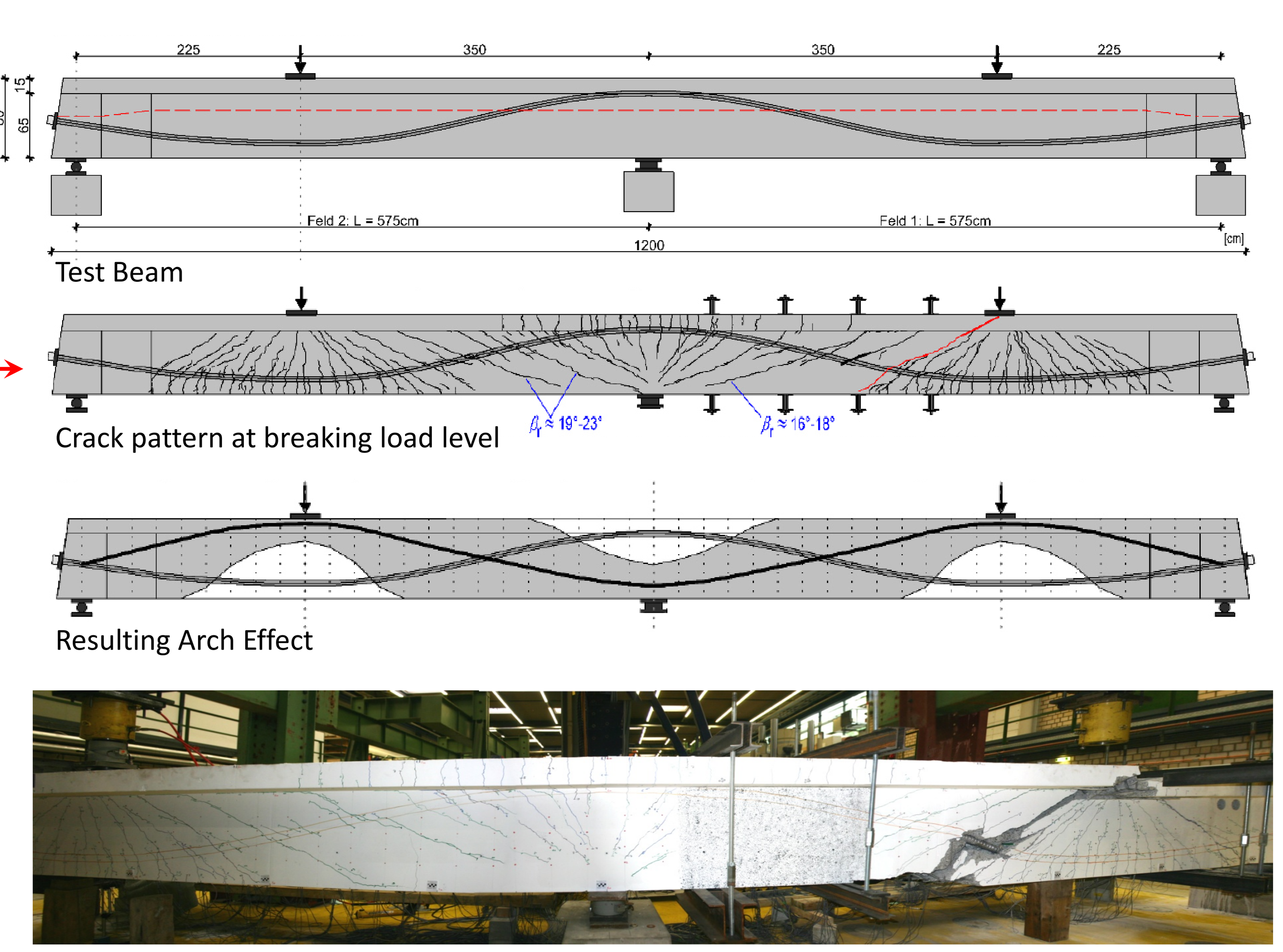


Fig. 6: Arch Action Model to determine shear capacity [5]

Literature cited

[1] Federal Highway Research Institut: Bridge Statistics, 03.2017.

[2] Kaschner, R. et al.: Ermittlung relevanter Bauwerke zur Ertüchtigung des Brückenbestands der Bundesfernstraßen, BASt, 2009.

[3] Richtlinie zur Nachrechnung von Straßenbrücken im Bestand (Nachrechnungsrichtlinie – Structural Assessment Guideline), BMVBS, Berlin/Bonn 2011.

[4] Hegger, J. et al.: Beurteilung der Querkraft- und Torsionstragfähigkeit von Brücken im Bestand – kurzfristige Lösungsansätze. Schlussbericht zum FE 15.0482/2009, Bergisch Gladbach, 2014.

[5] Maurer, R., et al.: Untersuchungen zur Querkrafttragfähigkeit an einem vorgespannten Zweifeldträger, BASt Heft B 120, Bergisch Gladbach, 2015.

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