TESTS ON CONCRETES OF LIQUID AND GROUT CONSISTENCY

by

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1. Introduction

Concretes of liquid and grout consistency, of an Abrams slump value over 10 cm, used for prefabrication, underwater concreting, slot walls, may be considered as special concretes from certain aspects. Also these concretes are subject to water tightness and strength requirements, met only by homogeneous and well compacted concretes.

Scarcity of literature data and specifications on the relevant technology parameters induced to determine them by tests, the results of which will be presented below.

2. Testing program

The same cement type, and Danube sand and gravel of identical max. size, in three fineness grades, have been used to make three concrete grades. A further variation was to test three different consistencies and plasticizer effect. Mix compositions are compiled in Table 1.

All mixes have been tested for the important properties: slump, density, real cement content and water/cement ratio. 20 cm side cubes and cylinders ∅ 15 cm and 30 cm high have been made to be tested for compressive and splitting strength, respectively, at 28 days of age.

3. Test materials

The applied Portland cement of Tatabánya was of grade 500 (tested in earth-moist mortar), of 2.94 g/cm^3 density; initial setting time 2 h 50 min, final 5 h 10 min; setting water was 29%. Grinding fineness: 1% of residue on sieve No. 900 and 6% on sieve No. 4900. 28-day cube strength was 540 kgf/cm^2 and tensile strength 44 kgf/cm^2 determined by earth-moist mortar test

Table 1

Testing program

Test No.	Concrete grade kgf/cm²	Slump cm	Design cement dosage kg/m³	W/C	Aggregate fineness modulus	Plasticizer
1	B 100		200	1.20		
2	B 280	10	350	0.70		
3	B 400		500	0.45		
4	B 100		200	1.20		
5	B 280	15	350	0.70	5.21	
6	B 400		500	0.45		
7	B 100		200	1.20		
8	B 280	20	350	0.70		
9	B 400		500	0.45		
10	B 100	10	180	1.20		
11	B 400		500	0.45		
12	B 100		180	1.20		
13	B 280	15	320	0.70	5.81	
14	B 400		500	0.45		
15	B 100		180	1.20		
16	B 400	20	500	0.45		
17	B 100	10	220	1.20		
18	B 400		400	0.45		
19	B 100		220	1.20		
20	B 280	15	400	0.70	4.51	
21	B 400		500	0.45		
22	B 100		220	1.20		
23	B 280	20	400	0.70		
24	B 400		500	0.45		
25	B 280	10	350	—		
26	B 280	15	350	—	5.21	
27	B 280	20	350	—		
28	B 100	10	180	—		Plastol
29	B 100	15	180	—	5.81	Plastol
30	B 100	20	180	—		Plastol
31	B 100	10	220	—	4.51	Plastol
32	B 100	20	220	—		Plastol

The aggregates of three different fineness moduli have been composed of rounded Danube sand and gravel, and of graded gravel mixed in different proportions. The sand-and-gravel was 0.1 to 40 mm size, with an Abrams fineness modulus of 4.04, and the graded gravel was 10 to 40 mm size, with a fineness modulus of 7.67. Fineness moduli of aggregates in the Ist, IInd and IIIrd group were 5.81, 5.21 and 4.51, respectively.

0.4 per cent by weight of cement of "Plastol" made by Chemical Co., a sulphite liquor-based plasticizer has been admixed to some concretes.

4. Test procedure

Components were dosed by weight, based on trial mixes. Concrete was mixed first dry and then wet for 3 min. each, in a positive type mixer. Two consecutive Abrams slump tests gave results differing by not more than 2 cm.

From every batch, 5 cubes and 2 cylinders were cast in steel moulds. Corners and edges were filled out by rodding. No stamping or vibration has been applied. Green concrete densities were checked on two cubes each and applied to calculate the real composition.

Specimens were kept under PVC sheet for 24 h, then stripped and stored at room temperature under several layers of wet burlap up to 28 days.

Density and strength tests have been made at 28 days. Cubes were tested for compressive strength.

For splitting strength tests, cylinders were loaded with the intermediary of two hardwood laths 1.5 cm wide along two opposite generatrices. Splitting strength was calculated from the maximum force needed for splitting:

$$H = \frac{2P}{3{,}14\ \mathrm{d.h}} \qquad [\mathrm{kgf/cm^2}]$$

where P splitting force in kgf
d cylinder diameter in cm
h cylinder length in cm.

5. Evaluation of test results

5.1 *Green concrete tests*

Green concrete tests are involved in evaluating relationships between technology parameters such as w/c ratio, slump, density, cement content of green concrete, aggregate fineness modulus and plasticizer effect.

Relationship between w/c ratio and slump. In Fig. 1 on Abrams slump R vs. w/c values, slump values of mixes of the same design strength and made of the same aggregate have been connected. Thus, each data series refers to concretes of the same composition but different w/c ratios hence slump values. The not too numerous tests have led to the conclusions that:

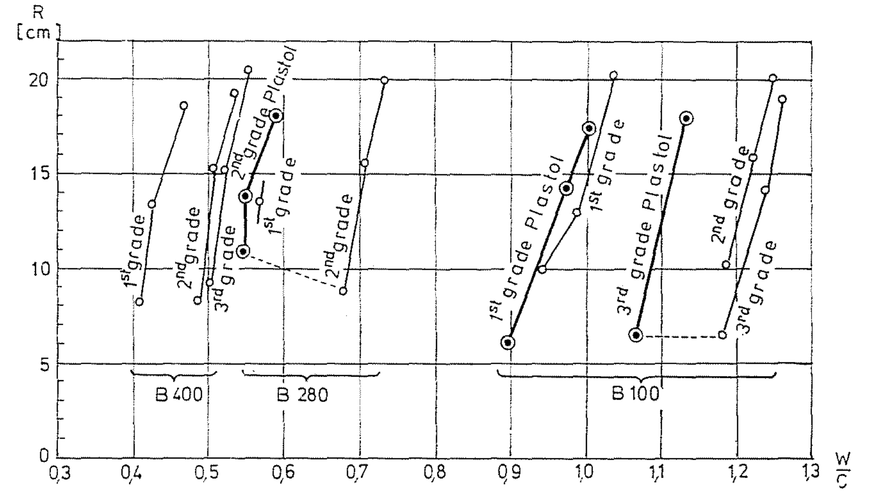

Fig. 1

— increasing w/c ratios belong to increasing slumps, the cement contents being about identical;

— in this range, the consistency determined by slump tests is rather sensitive to w/c changes, an increase by 0.1 raising the slump by about 15 cm for an otherwise identical composition. Thus, a slight change of water or aggregate moisture much alters the slump. Hence, in a site, slump values may vary over a wide range;

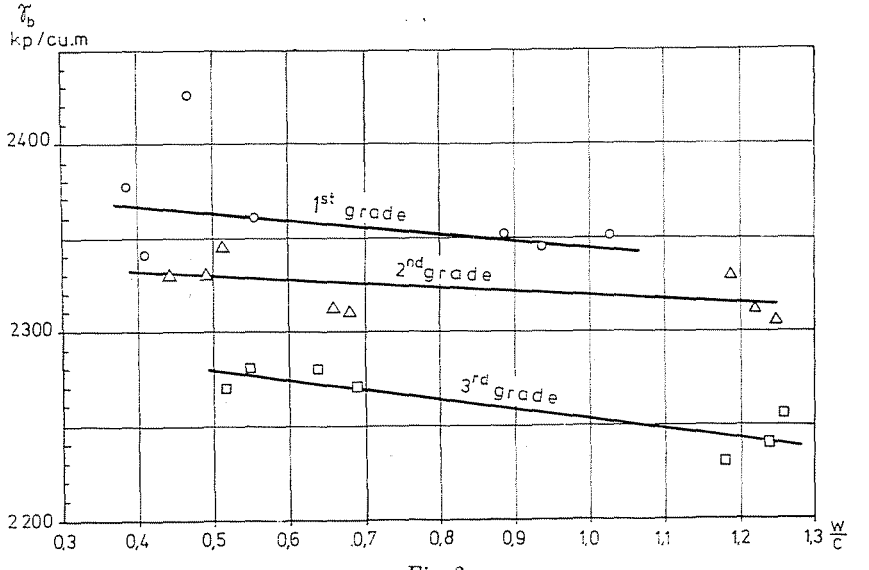

Fig. 2

— this phenomenon may also be interpreted so that to change the consistency controlled by slump a moderate w/c ratio change is sufficient, an advantage from strength aspects. This fact appears also from Fig. 7 showing the relationship of strength and slump values in item 5.2;

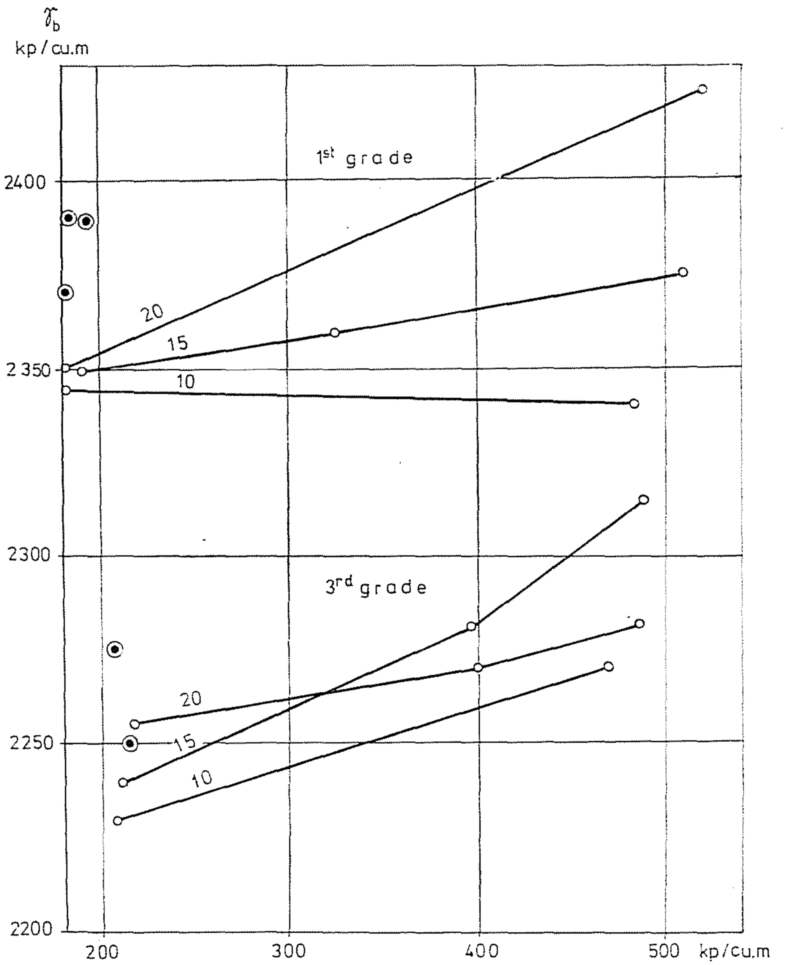

Fig. 3

— for a given design strength, an increased aggregate fineness (from I to III) requires a higher w/c ratio to obtain the same consistency: decrease of the fineness modulus from 5.8 to 4.5 required to increase the w/c ratio by 0.1 and by about 0.25 for high and low strength concretes (grades B 400 and B 100, resp.), in spite of having increased the cement dosage for aggregates with more sand, reducing in itself the w/c ratio;

— use of a plasticizer reduced the w/c ratio needed for a given consistency for aggregates II and III by about 0.15, while for aggregates type I no reduction was possible.

Relationship between w/c ratio and density. Fig. 2 shows green concrete densities γ_b vs. w/c ratio. Since only results classified according to aggregate fineness differed, concretes have been distinguished according to aggregates.

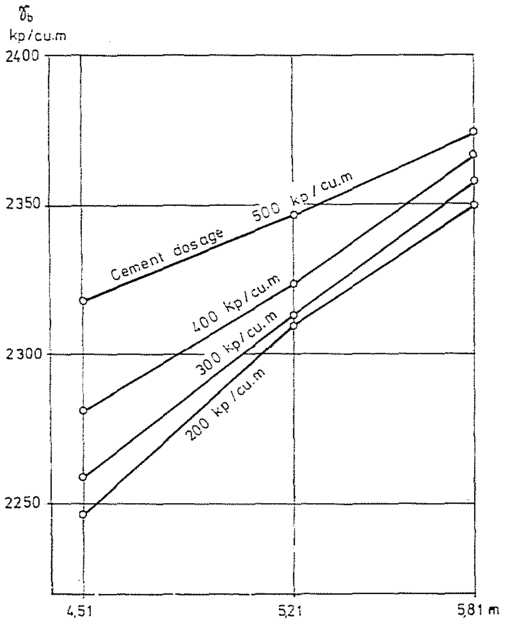

Fig. 4

It has been stated that

— density is most dependent on the aggregate fineness;

— the change of the w/c ratio alters but slightly the density, a reduction by 0.1 being responsible for a density increase by 20 to 50 kgf/cm³, primarily as a result of higher cement dosage.

Relationship between cement dosage and density. Variation of green concrete density vs. cement dosage c is shown in Fig. 3 for aggregate types I and III. The density is seen to increase about linearly with the cement content. According to earlier findings (see Ref.) for earth-moist, stiff and plastic concretes an increased cement dosage somewhat reduced the green concrete density, attributed to the lower density of low w/c cement paste than that of the aggregate. The opposite trend in the range of liquid consistencies may be explained by the excess water over that needed for a slightly plastic consistency. There is relatively more water even for a low cement content.

The plasticizer effect was manifest by reducing the cement dosage needed for the same consistency (especially for aggregates rich in sand), or by increasing the density for a given cement dosage, this, however, was not always the case.

Relationship between fineness modulus and density. Fig. 3 shows also that a lower aggregate fineness modulus reduces the concrete density. The same effect has been plotted in Fig. 4 for concretes of 15 cm slump. Dependence of density on aggregate fineness modulus m and cement dosage demonstrates that reduction of the fineness modulus from 5.8 to 4,5 reduces the density of concretes rich or poor in cement by about 50 and 100 kgf/m^3, respectively.

5.2 *Hardened concrete tests*

Compressive and splitting strengths at 28 days and green concrete characteristics have been confronted.

Water/cement ratio and compressive strength. Relationship between 28-day concrete strength and w/c ratio in Fig. 5 shows our test results to strictly follow

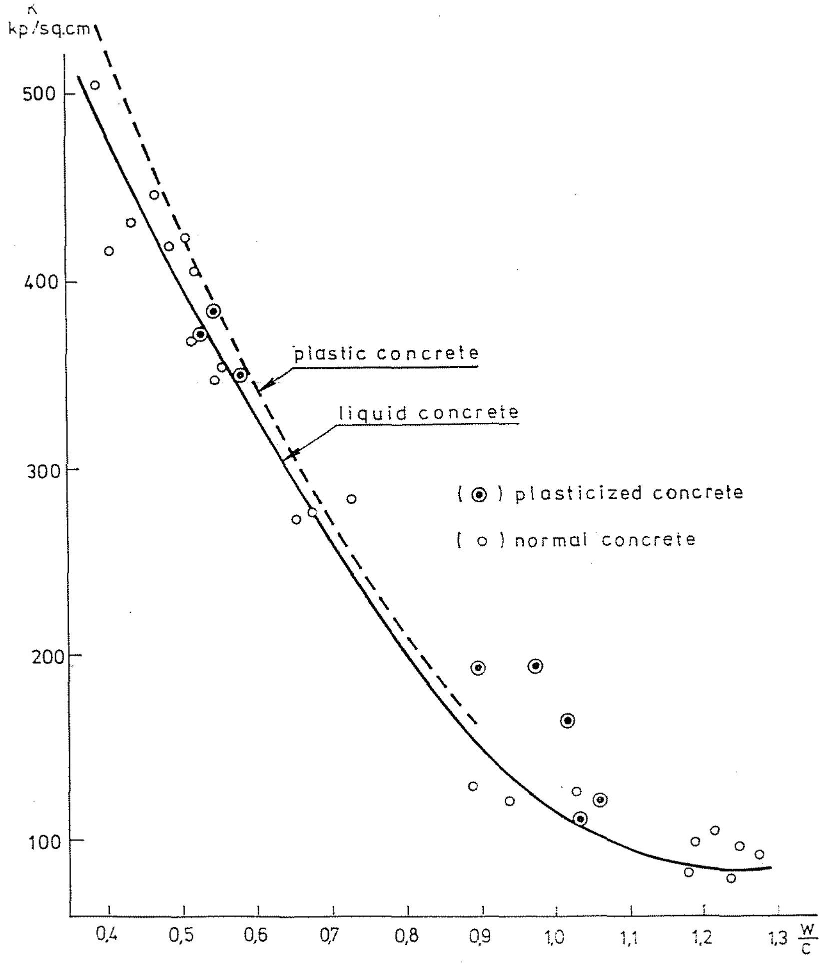

Fig. 5

the law established by several authors. Also earlier test results on plastic concretes have been plotted and the similarity is perspicuous. The plasticized concretes are stronger than normal concretes of the same w/c ratio in the range about $w/c = 1.0$. For w/c ratios about 0.5, hence for high-strength concretes, the same relationship is valid to both plasticized and ordinary concretes.

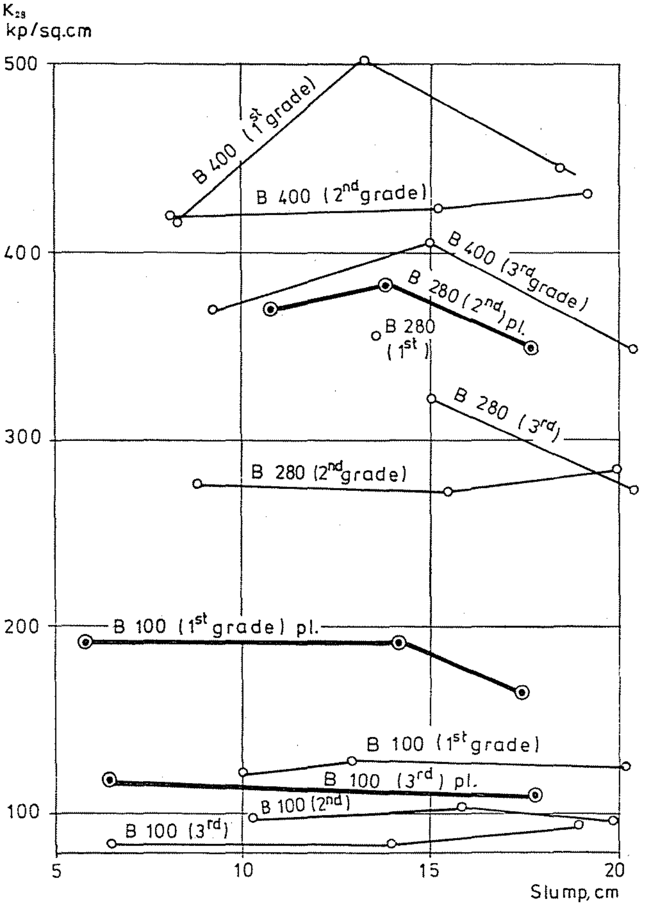

Fig. 6

Slump and compressive strength. Fig. 6 shows compressive strength vs. slump values. Results for concretes of identical composition are connected by straights, pointing out that mixes of slump values over 15 cm are mostly less strong than are those below 15 cm, the more peculiar because of the higher cement dosage of mixes of greater slump.

Plasticized concretes unambiguously exhibit strength gain.

Cement dosage and compressive strength. Cube strength was seen to grow about linearly with cement dosage.

The compressive strength of plasticized concretes is always higher than that of normal concretes of the same cement dosage, hence in final account, the effect of plasticizers to improve the consistency is manifest by strength increase or cement saving, also for concretes of liquid and grout consistency.

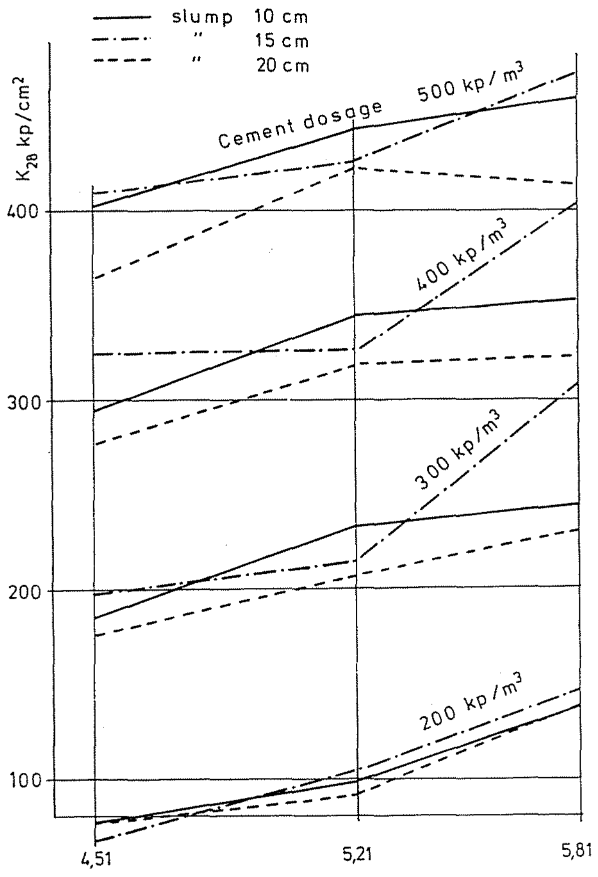

Fig. 7

Fineness modulus and compressive strength. Relationship between fineness modulus and cube strength for different cement dosages and slumps has been plotted in Fig. 7. A higher fineness modulus is seen to be accompanied by higher compressive strength; for any cement dosage and slump about the same strength gain may be reckoned with, disregarding random deviations. Increase of the fineness modulus from 4.5 to 5.8 brings about a strength gain by about 60 kgf/cm²; for low-strength concretes the percentage gain is higher.

6. Conclusions

The outlined tests have led to the following conclusions:

— Also in this range, consistency is sensitive to changes of the w/c ratio;

— green concrete density is but slightly affected by w/c ratio and consistency, but markedly by aggregate fineness;

— with increasing cement dosage, the density is also increased, as against that observed for plastic concretes;

— the relationship between w/c ratio and strength is similar to that obtained for normal concretes in our earlier tests;

— a slump over 15 cm mostly produced lower strength values;

— the ratio of splitting to cube strength was about

$$H_H = 0.07\ K_K + 3\ \text{kgf/cm}^2$$

in the range $K_K = 100$ to 500 kgf/cm^2;

— the use of a plasticizer is likely to be advantageous also in this range of consistencies, by its effect to reduce the w/c ratio needed to provide the desired consistency, especially for poorer aggregates;

— also the cement dosage can be reduced below that for non-plasticized concretes;

— in lower strength ranges, plasticized concretes were higher in strength than normal ones of the same w/c ratio. For high-strength concretes, no such effect could be demonstrated;

— for identical cement contents, the strength of plasticized concretes was higher than that of non-plasticized ones.

On the basis of these tests, suggestions could be elaborated to complete the concrete composition nomograms in the relevant *Technical Specifications.*

Summary

Technology parameters of concretes with Abrams slump values of 10 to 20 cm have been tested, with different aggregate fineness moduli, cement dosages, w/c ratios, cement grades, with or without plasticizer. From tests on green concretes, and from compressive and splitting tests at 28 days of age, the following conclusions could be drawn: consistency is sensitive to w/c ratio changes; w/c ratio and strength are related similarly as for ordinary concretes; concretes with slumps over 15 cm suffer a strength loss; plasticizers act favourably.

Reference

1. TALABÉR, J.—ERDÉLYI, A.—HORVÁTH, A.: Technology Test on Concretes for Hydraulic Engineering. (In Hungarian). Report, Department of Building Materials, Technical University, Budapest, 1971. Manuscript.

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