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Small Scale Models of PCPV for High Temperature Gas Reactors. Modelling Criteria and Typical Results

Modèles en échelle réduite de caissons en précontraint pour réacteurs à gaz à haute température. Techniques de reproduction et résultats typiques

Kleinmasstab-modelle von Spannbetonbehälter für Hochtemperatur-gas Reaktoren. Modelltecniken und Versuchergebnisse

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1. INTRODUCTORY REMARKS

1.1 For the static tests on PCPV, there have been used up to now, two main types of models which utilize different techniques and serve different experimental purposes: one is the model in resin which allows tests to be carried out in the elastic range as an alternative to calculation processes; the other one is the concrete model, especially devised for failure tests.

The geometrical scales for concrete models usually range from 1/10 to 1/30 (refs. 1 ÷ 5). However, there are many examples of reproduction on a larger scale.

Smaller scale ratios allow, at a same cost and at a same time schedule, the test of many more models so that the design can be improved through further experimental stages on the various subsequent models.

However, a small scale reproduction imposes some limits on the modelling. For instance, the concrete model does not correctly reproduce the stresses due to the fact that the dead load, cannot be modelled. At any rate the impact of the only dead load on the general state of stress is negligible.

Besides that, a small scale model needs in some cases a simplified schematization of the cable pattern which usually leads to an improvement of the cable specific power. This brings to light the practical possibility of adopting, for the prototypes, such high powered unit cables (in the range of 1,000 - 2,000 tons) (refs. 6 and 7).

With regard to the choice of the concrete for the models, that requires the reduction of the size of the aggregates, advanced researches are carried out in many laboratories, sometimes at a very sophisticated level.

However, there are some limits of approximation to the physical reality, suggested by the purposes and the nature of the tests.

Generally, it may be considered sufficient that the characteristics of the concrete selected for the models fit into the dispersion range of the properties of the normal concrete (max aggregate size 3 cm).

Furthermore, always within the limits and the aims of the research, it is not necessarily required that all the properties of the material be fully respected.

For example, it does not seem logical at all, to reduce the grain size of the aggregates in the true scale ratio. This leads to worst conditions in the model as far as the crack distribution is concerned; on the contrary the mechanical properties must be imperatively respected.

A correct scaling down of the aggregates means that there is an increase in the percentage of cement mortar. In turn larger percentage of cement mortar increases the creep of the material and, because of a great evaporation due to the higher water content, also its shrinkage. A theoretically correct reproduction of the conglomerate is not, therefore, obtainable in practice, and the maximum size of the aggregates is usually determined in function of the clearances between the reinforcing steel bars and cable ducts.

In addition, the correlation between the model and the prototype becomes more and more difficult because of the different lives experienced by the two structures. In fact, during the design stage, the model must necessarily be tested in the shortest time; whereas the prototype comes into use some years after its building.

For the model, it is therefore impossible to take into account the changes which arise in the properties of the material due to the long standing (in any case the ageing of the concrete is a minor effect).

In addition, for the small scale models it must be evidenced that the correct modelling of the liner, whose behaviour is so important for the true structure, can hardly be achieved.

The research through the models on creep and shrinkage effects does not seem, at present, to offer and adequate reliability.

1.2 The main purpose of the model testing is the estimation of the safety margins of the structure.

Since several years researches on the strength of concrete under multiaxial stresses have been carried out on specimens with encouraging results, with the aim of making it possible to correlate the local tensor of the stresses with the collapse values and then to deduce the local safety factor.

Nevertheless, a failure test on the model gives a more reliable overall safety factor of the structure, because it takes into account the plasto-viscous type of deformation processes, which are strongly accentuated in triaxial stress conditions, and consequently the stress redistribution coming from these processes. Such plasto-viscous effects can also be observed in triaxial test on concrete specimens, when the failure is mainly due to shear stresses.

Therefore, the problem is how to select the criteria for the carrying out of the ultimate tests. The failure tests of explosive type (pressured gas) arise some important problems in connection with the intrinsic difficulty to learn the failure mechanism during the explosive phase. An endurance collapse test does not reproduce the possible failure mechanism of the prototype. The failure tests usually carried out are of a relatively fast type (1 - 2 $Kg/cm^2/min.$) and they consist of a gradual increase of the internal pressure, and of the step by step deformation and cracking processes measurements, up to the structural collapse.

1.3 It is usually difficult to obtain a complete picture of the state of stress from the tests performed in the working range. Since the structure under test is usually stiff, the deformations to be measured are very small.

Besides that, it is difficult to obtain strain or deflection measurements on the internal surface, because of the existance of a liner under pressure, and on the external surface because of the existence of the cable anchor heads, ribs and penetrations.

The measurement of the strains and thus the evaluation of the stresses, are therefore rather incomplete.

However, the adoption of continuous lines of small strain gauges has proved to be quite valid.

In this way, for instance, the congruence between the summation of the local strains and the total deflections may be checked. A comparison between this kind of measured results and calculation predictions (ref. 8) becomes thus possible to some extent.

1.4 To conclude, it is worth of pointing out a few disadvantages caused by the schematization of the prestressing system needed to satisfy the reduced scale of the model.

The cable of the model,reduced in accordance with the scale ratio, leads to an improvement of load losses because of a greater impact of the cable head settlements. This means the performance of frequent checking and, sometimes, additional restressing interventions.

1.5. As to measurements of surface stresses in the elastic field, due to the internal pressure, the testing made on a non-prestressed epoxy resin model may be of some interest. The high Poisson ratio of the resins (about 0.4) can be reduced to values ranging from 0.25 to 0.30 with the addition of suitable aggregates.

The main advantage of these epoxy resin models consists of the fact that the effects of their penetration on the axisymmetric structure can be measured by drilling in sequence on the same model.

Some tests made at ISMES (Experimental Institute for Models and Structures) on epoxy resin models have been quite satisfactory.

However, as it has been already said, the modern trend of the research in this field is to emphasize the failure tests.

This interest is due to the need to determine the failure mechanism of the structure and the relevant safety margins that cannot be satisfactorily derived from the calculation tools.

The present paper describes the most recent researches carried out at ISMES on the failure tests of the PCPV small scale models.

The tests have been carried out for CPN (Nuclear Design and Construction Center) of ENEL (Italian State Electricity Board) as a part of the general research programme sponsored by DSR (Studies and Research Direction) of ENEL, with the aim of investigating more advanced techniques in the field of prestressed concrete vessels models for nuclear reactors.

2. MODEL TESTING TECHNIQUES

2.1. The tests carried out at ISMES in the last 10 years in the field of prestressed concrete vessels for nuclear reactors include:

a) concrete models (complete or portions) in scale 1 : 20;

b) epoxy resin models in scale 1 : 50;

c) photoelastic plain models for the study of details (areas concerning the penetrations, gussets, etc.).

Some of the techniques which have been used at ISMES for concrete models as well as the main results of the tests, with particular reference to the most recent model are included in this part of the report (figs. 1 and 2). As regards the concrete models tested until now, the following techniques and simplifications were used.

2.2. Liner

A reduced scale steel liner (actual thickness 2 - 4 cm)

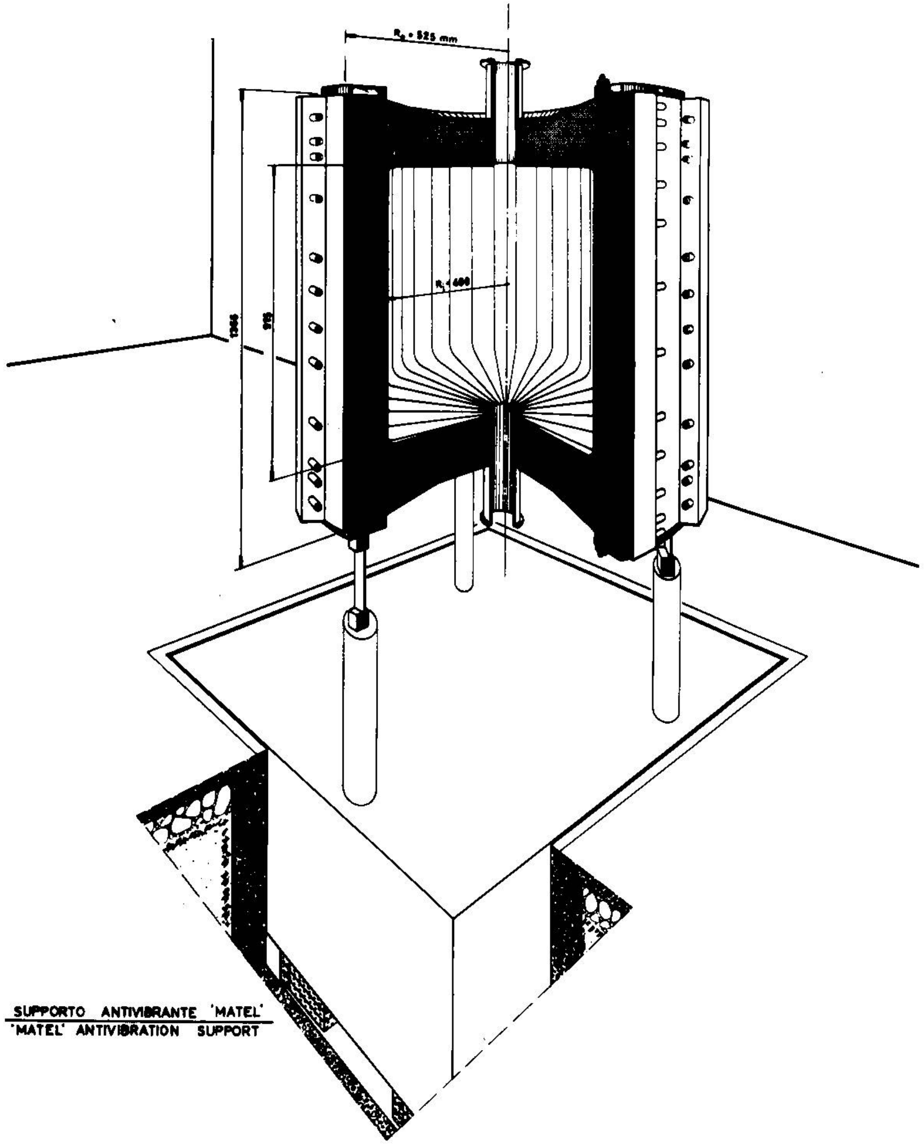


FIG. 1 ARRANGEMENT OF THE MODEL FOR TESTING
DISPOSITION DU MODELE POUR LES ESSAIS
EINRICHTUNG DES MODELLS FÜR DIE VERSUCHE

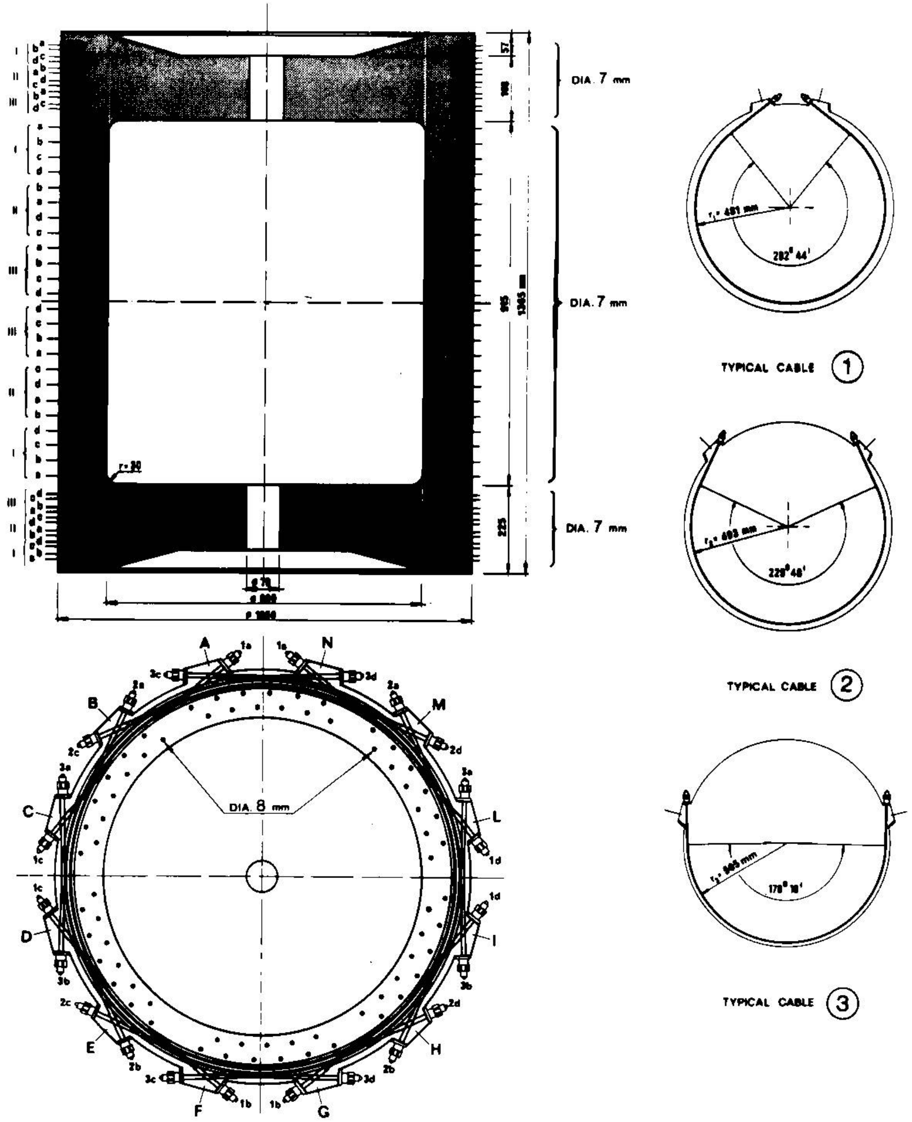


FIG. 2 LAYOUT OF PRESTRESSING CABLES
SCHEMA DES CABLES DE PRECONTRAINTRE
MODELL VORSPANNUNG

showed a brittleness at weldings, especially in the range of the large deformations occurring during the ultimate tests.

After a number of unsuccessful experiments during which sealed rubber bags were used, it was decided to replace the steel liner with a more ductile copper liner (ref. 9) allowing larger deformations and thus leading to the collapse of cable systems.

2.3 Prestressing cables

A correct reproduction of the prestressing system is very important. The solution adopted for the models consists in the use of the same harmonic steel wires of the actual structure 6 - 7 - 8 mm in diameter (which is the same diameter as that of the wires chosen for the prototype).

In order to distribute the prestressing loads uniformly the monowire cables were used.

2.4 Mild-steel reinforcement

The mild-steel reinforcement installed near the liner and outer surfaces so as to distribute the cracks are reproduced in the model by electro-welded steel netting. The reinforcement in the stress concentration areas, such as the penetrations and gussets, is obtained with steel cages of small diameter wires (ø 3 - 5 mm).

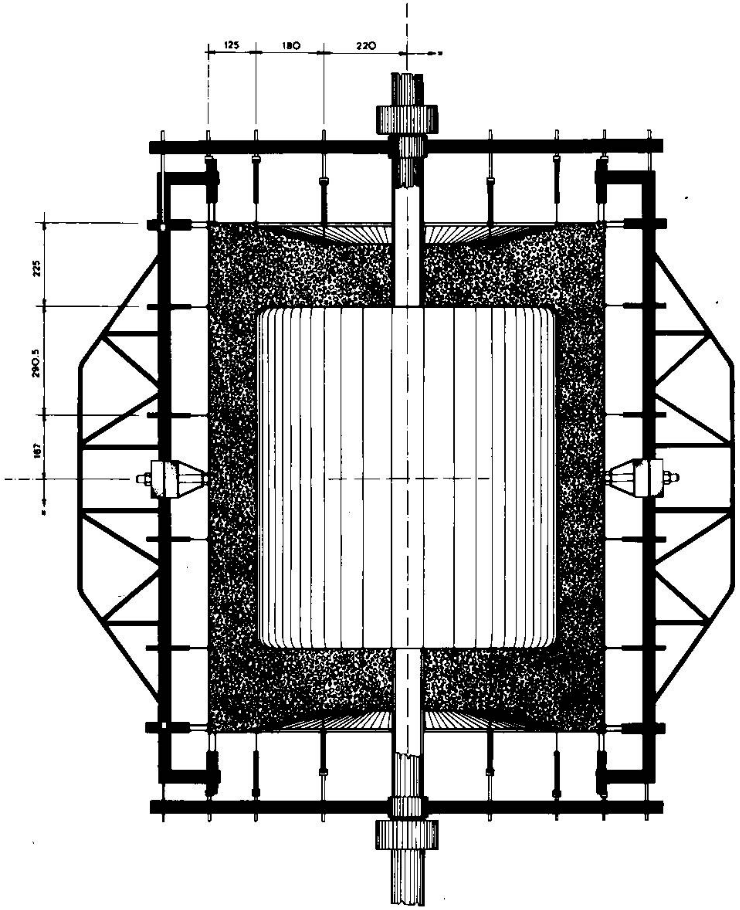
2.5 Instrumentation

The measurements are especially difficult, considering that the concerned deformations are slight. Several attempts to obtain information from the inside of the castings and the surface of the liner were made, which gave rather unreliable results.

Furthermore, taking into account that the internal instruments and their connections cause discontinuities leading to the starting of the cracks, only external measurements were taken, measuring only the temperature distribution by means of several thermocouples located inside.

As far as the measurement of the deflections is concerned at first the measurements were taken by using an external rigid reference frame. These instruments, placed one opposite the other on the frame, measured the diametrical and axial deflections to produce the average value.

Later, an intrinsic measurement system of the deflections was preferred, fixing a series of displacement transducers to four rigid invar frames anchored directly onto the model. The transducers are arranged in two orthogonal diameters on each slab and along the four corresponding generatrixes on the cylindrical walls. Fig. 3 clearly shows the arrangement of the measuring system.



WTK 5 HOTTINGER TYPE DISPLACEMENT TRANSDUCER

FIG. 3 APPARATUS FOR MEASURAMENT OF DEFLECTIONS
TREILLIS DE MESURE DES DESPLACEMENTS
MESSVORRICHTUNG DER VERSCHIEBUNGEN

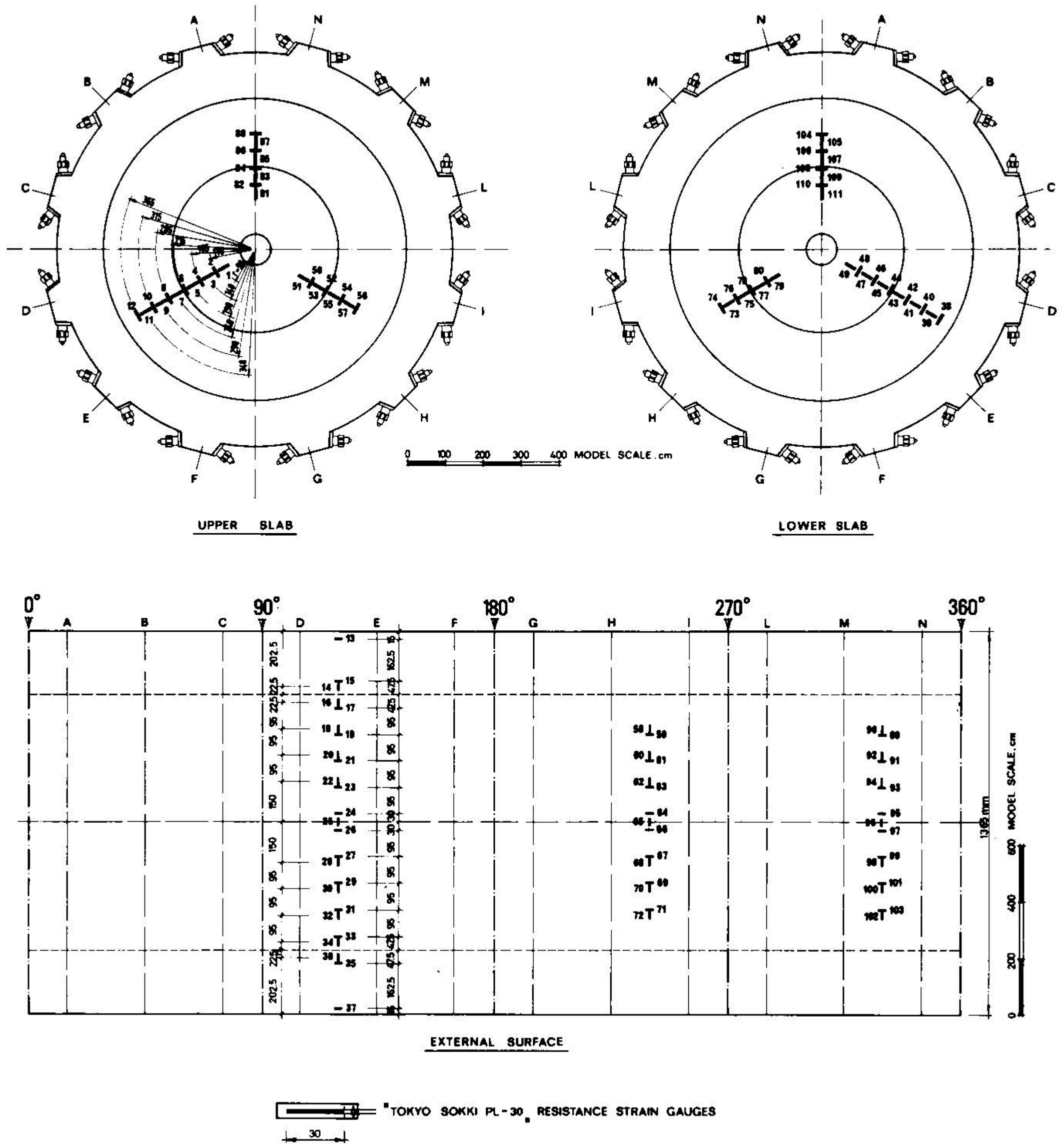


FIG. 4 LAYOUT OF RESISTANCE STRAIN GAUGES
POSITION DES JAUGES A FIL RESISTANT
ADNORDNUNG DER DEHNUNGSMESSSTREIFEN

It should be pointed out that this arrangement allows the true deformed surface of the structure under test to be determined.

2.6 Pressurization system

Internal hydrostatic pressure is applied to the model. The system consists of an oil pump (flow rate 10 lt/min) capable of operating up to 400 Kg/cm^2, connected to an interchange oil-water piston. An electronic operated pumping station allows the pressure to be regulated with a motorized valve. The final value of the pressure can be reached in a previously chosen length of time, with steps of 0,1 Kg/cm^2.

2.7 The tests on concrete models carried out at ISMES in recent years include:

a) prestressed concrete model of vessel for the "Dragon Project" (HTGR type)

b) prestressed concrete model of vessel for the THTR project.

The results obtained from the tests of the above - mentioned model b) suggested the opportunity to complete the tests on partial models of the structure: i. e. the end slabs and the barrel. The main purpose of the additional researches was to assess the behaviour of the single structural elements up to collapse. On the basis of the results, it was decided to carry out other experiments on three models with thin walls.

On the first model, conventionally named CPS 3/1, where penetrations both of barrel and slabs were reproduced, tests were completed by the beginning of 1972. The failure of the model was due to the collapse of the hooping cables at a pressure of 119 Kg/cm^2.

The other two models, CPS 3/2 and CPS 3/3, were built at the same time and were similar to the previous model in shape and size, with the exception of:

a) the penetrations were not reproduced

b) the prestressing installation was schematized so as to make the structure as axisymmetric as possible

c) the steel of the prestressing cables which in these two models was replaced with stabilized steel.

The only difference between CPS 3/2 and CPS 3/3 is related to the barrel hooping cables (ø 6 mm for CPS 3/2, ø 7 mm for CPS 3/3) and the vertical cables (ø 7 mm and ø 8 mm, respectively).

3. DESCRIPTION OF CPS 3/3 MODEL

3.1 The model, shown in fig. 1, reproduces the project plan of a prestressed concrete vessel for a "THTR" gas reactor. The vessel is cylindrical with two flat closure end slabs. The inside part is lined with a metal liner. The concrete is prestressed vertically and horizontally with systems of monowire cables as in the BBR System. The operating pressure of the reference prototype is 40 Kg/cm^2.

A damper system (fig. 1) of "Matel" rubber bricks, on which the supporting concrete block of the model stands, allows a good isolation as regards accidental external dynamic actions. The concrete block leaning on the rubber bricks supports the model by means of a flexible system of steel pipes and blades which offers a negligible radial restraint.

Table I (see page 10) lists the main characteristics of the model. The casting of the model was carried out in one stage.

3.2 Measuring instruments

The instrumentation of the model is summarised in the following Table II:

Type of measurement	Type of instrument	No.
Deflections of the cylindrical wall and slabs	Inductive displacement transducers. Hottinger type W 1 and W 5	80
Strains measured on the outer sufaces	Electrical resistance strain gauges Sokki Kenkyujo type	111
Pull check in the prestressing cables	Load cells ISMES type	41
Temperature distribution in pours	"Thermoelectric" type thermocouples	24
Internal model pressure	Hottinger type extensimetric pressure cells P 3 M 50 and P 3 M 200	2

During the tests the readings of the above instruments were carried out at the speed of 1 point a second, with Hottinger commutation apparatus with automatic recording. The values are also independently recorded on perforated tape and then elaborated on an HP Computer.

Moreover, multichannel pen recorders were used for a real time reading of the more representative instruments.

During the ultimate tests an acoustical noise emission recorder was used in order to record the intensity of the crack propagation versus the rising pressure.

TABLE I

GEOMETRICAL	DATA	Scale	1 : 20
		Total height	H = 136,5 cm
		Internal height	h = 91,5 cm
		Slab thickness	hs = 16,8 cm
		Height of prestressed band of slabs	hp = 22,5 cm
		Outer radius	Re = 52,5 cm
		Inner radius	Ri = 40,0 cm
CONCRETE	Composition	Grain size curve	cubic
		Aggregates	Torre del Lago sand up to 1 mm Limestone fragments from Zandobbio up to 8 mm
		Cement	Portland 425 - water/cement ratio 0,475
	Mechanical properties	At the time of testing approx. 1 year after casting	
		Compressive strength	(test specimen 16 x 16 x 16 cm) R_{cc} = 530 Kg/cm^2
		Tensile strength	(cylindrical test specimen ø 10, h = 20 cm, Brasilian test) R_{ct} = 32 Kg/cm^2
		Young modulus	(up to 120 Kg/cm^2, E_c = 400.000 ÷ 420.000 Kg/cm^2
PRESTRESSING	Mechanical properties	Prestressing system	BBR
		Monowire cables	stabilized steel ø 7 - 8 mm
		Proportionality limit	K_s = 0,1% = 151,3 Kg/mm^2 ø 7 mm 143,7 Kg/mm^2 ø 8 mm
		Yield limit	K_s = 0,2% = 153,0 Kg/mm^2 ø 7 mm 146,0 Kg/mm^2 ø 8 mm
		G. U. T. S.	K_{rag} = 175,0 Kg/mm^2 ø 7 mm ø 8 mm
		Young modulus	E_a = 21.000 Kg/mm^2
	Layout	Vertical cables	36 x 2 = 72 monowire cables ø 7 mm
		Slab cables	Hooping monowire cables ø 7 mm, nos. 3 hooping for each layer (Layout patent ENEL, Dr. Scotto). Total nos. 12 layers for each slab 12 x 3 x 2 = 72 anchor heads on 12 anchor ribs at 30°. (ref. 10).
		Barrel cables	Hooping monowire cables arranged as for slabs.
	Initial pulls	Vertical cables	5208 Kg (58,9% UTS) per cable
		Slab cables	5541 Kg (82,3% UTS) per cable
		Barrel cables	4122 Kg (61,2% UTS) per cable
		Average friction coefficient of the hooping cables	f = 0,15 (^)
		Cable ducts	mild steel ø 8 - 10 mm (slab barrel) ø 10 - 12 mm (vertical)
		Liner	Annealed copper bag 3 mm thick

(^) Determined by experimental measurement on models.

4. TEST PROCEDURE

The tests carried out on the model can be summarized as follows:

4.1 Prestressing

The prestressing sequence has been chosen so as to obtain the better distribution of the stresses induced by the cable pulling during the different stages and to avoid any tensile stresses in the structure (fig. 5). Instrumentation reading:

- resistance strain gauges on the external surface of the model;
- load cells on cable anchor heads.

Before carrying out the pressure tests, due to the losses in the cables, the prestressing was repeated to restore the required theoretical conditions.

4.2 Internal pressure tests

The internal pressure tests were carried out as follows:

a) First pressure cycles (0 - 40 Kg/cm^2): by means of a multi-channel pen recorder, some typical measuring instruments were read in order to check the behaviour of the model.

b) Pressure cycles in working conditions (5 - 40 Kg/cm^2) at ambient temperature. All the measuring instruments were read.

c) Pressure cycles in working conditions (5 - 40 Kg/cm^2) internal water temperature 44°C (Δt across the wall: 10°C).

d) Test with increasing pressure up to starting of clearly visible cracks, internal water temperature 44°C. First visible crack pressure 90 Kg/cm^2.

e) Pressure cycles as in c).

f) Overpressure test, up to 115 Kg/cm^2. Internal water temperature 44°C.

g) Pressure cycles as in c).

h) Collapse test. Internal water temperature 44°C. Collapse pressure 140 Kg/cm^2.

5. TEST RESULTS

5.1 Prestressing

In the diagrams of fig. 6 the pull losses of several cables of the three models at the anchor heads are shown both during and after the prestressing stages. With regard to the evaluation of these losses the observations already made in the introductory remarks should not be for-

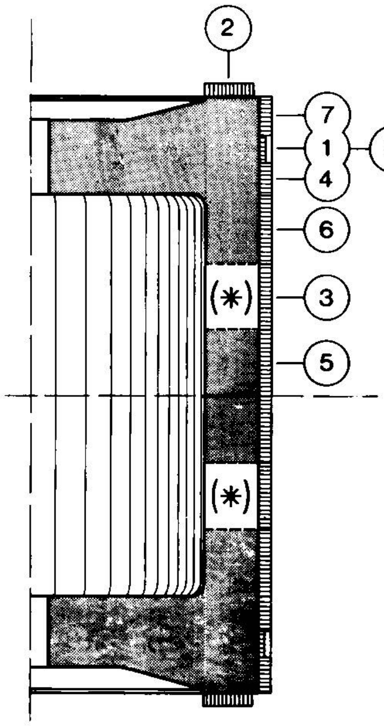


FIG. 5 PRESTRESSING SEQUENCE

SEQUENCE DE PRECONTRAINTE

FOLGE DER VORSPANNUNG

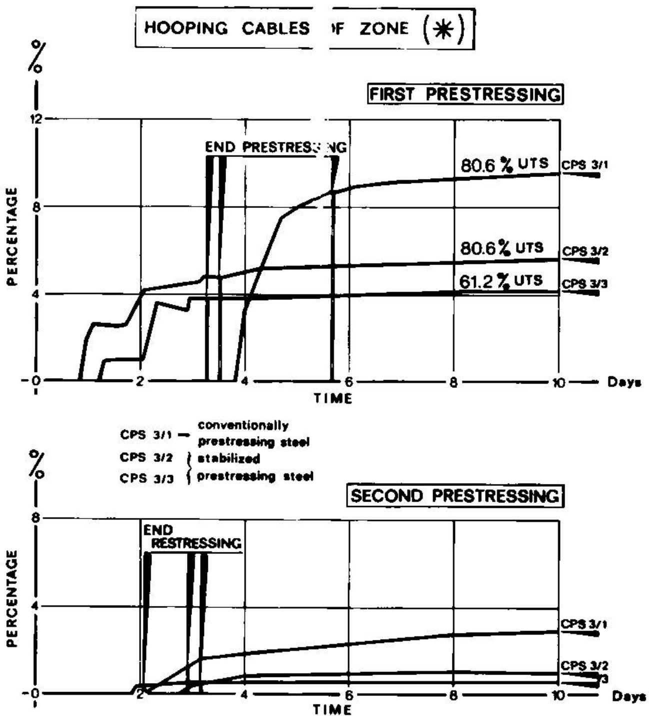


FIG. 6 LOAD LOSSES AT CABLE ANCHOR HEADS

PERTES DE PRECONTRAINTE MESUREE AUX TETES D'ANCRAGE

KRAFT VERLUSTE AN DEN VERANKERUNGEN

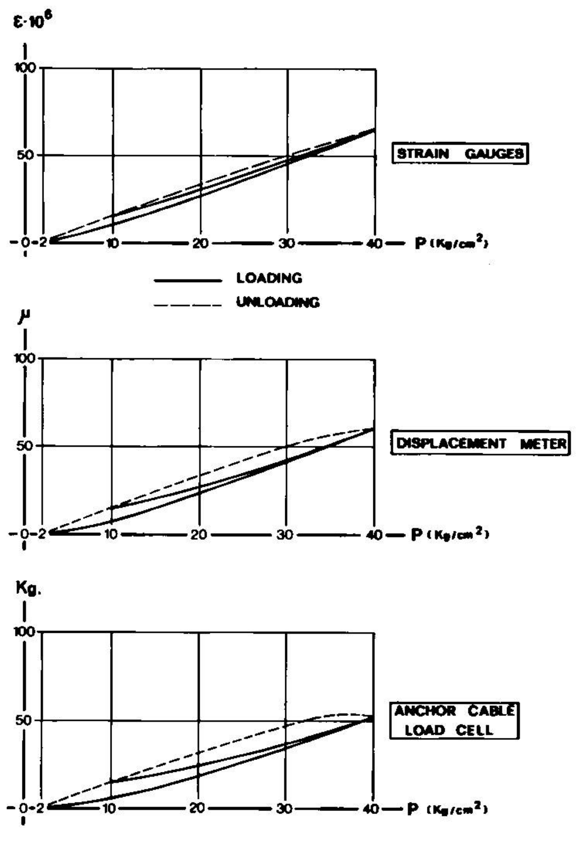


FIG. 7 TYPICAL BEHAVIOUR OF THE MODEL DURING LOADING CYCLES

COMPORTAMENT TYPIQUE DU MODEL PENDANT LES CYCLES DE PRESSION

TYPISCHES VERHALTEN DES MODELLS WÄHREND DEN VERSUCHEN

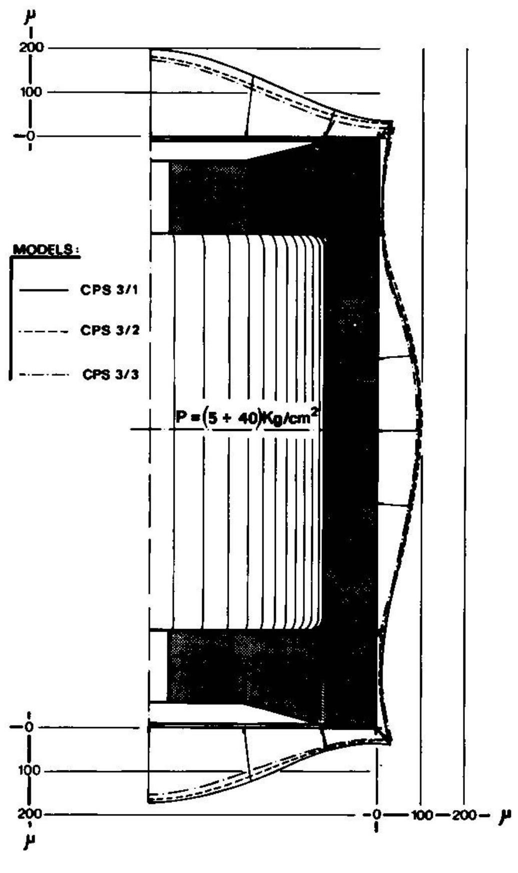


FIG. 8 COMPARISON BETWEEN THE OUTSIDE SURFACE DEFLECTIONS FOR AN INTERNAL PRESSURE

COMPARAISON ENTRE LES DEFORMATIONS DE LA SURFACE EXTERIEURE POUR L'EFFET D'UNE PRESSION

VERGLEIG ZWISCHEN DEN VERSCHIEBUNGEN FÜR INNENDRUCK gotten. In fact, owing to the short length of the cables of the model, even a small settlement of the anchor heads leads to a not negligible pull loss.

However, although in qualitative terms, it can be ascertained that the use of stabilized steel gives lower losses than normal steel. In fact, being the pulling of the cables over the 80 % of their G. U. T. S. they showed losses not greater than 5 - 6 % after prestressing (in comparison with the 10% of normal steel) and smaller than 1, 5% after the restressing.

5. 2 Pressure tests

As regards pressure tests in the range of working conditions and up to the collapse, carried out as per paragraph 4. 2, it should be noted that:

5. 2. 1 After the first pressure cycles the load - deformations diagrams for the working conditions even developping hysteresis loops, as shown in fig. 7, are repeatible as long as the prefixed upper and lower load limits remain unchanged.

5. 2. 2 During the first cracking tests, for pressures over 65 Kg/cm^2 the first microcracks was experienced along the central band of the barrel, as the strain measurements shown in fig. 9 indicate.

The development of this process is also evidenced by the deflection measurements in figs. 10 and 11. However, the cracks appeared clearly visible only from the above said pressure of 90 Kg/cm^2 (crack width 0, 1 ÷ 0, 2 mm).

In spite of microcracks the behaviour of the structure, coming back to the working condition limits, remains elastic and practically linear, very similar in fact to the original behaviour (ref. to fig. 12). This is due to the fact that the steel of the cables remains still elastic and the cracks affect only a cortical external limited region of the PCPV.

5. 2. 3 Over pressure test up to 115 Kg/cm^2 showed an increase in the state of cracking, limited however to the central band of the barrel due to the fact that the behaviour of the cable was still totally elastic.

Coming back to the working condition limits the structure does not recover its previous elastic behaviour (ref. to fig. 12) but the new curve, under cycling in the working pressure range, is mantained fairly well.

In fig. 13 radial displacements in the equatorial area of the barrel are shown, measured for the different overpressure test cycles. As may be seen, the values of these displacements, although following different paths, practically concide at the maximum pressure point reached in the previous cycle. The same behaviour is evidenced also in the measurements of the load increase in the vertical prestressing cables (see fig. 14).

INITIAL CRACKING TEST

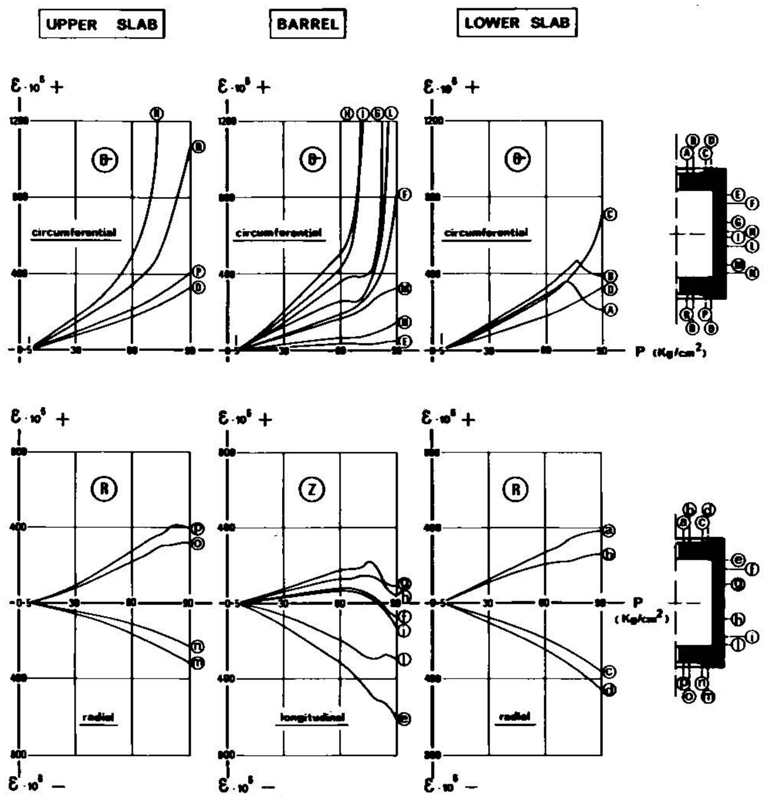


FIG. 9 STRAINS
DEFORMATIONS
DIAGRAMME DER ε_R - ε_θ - ε_Z

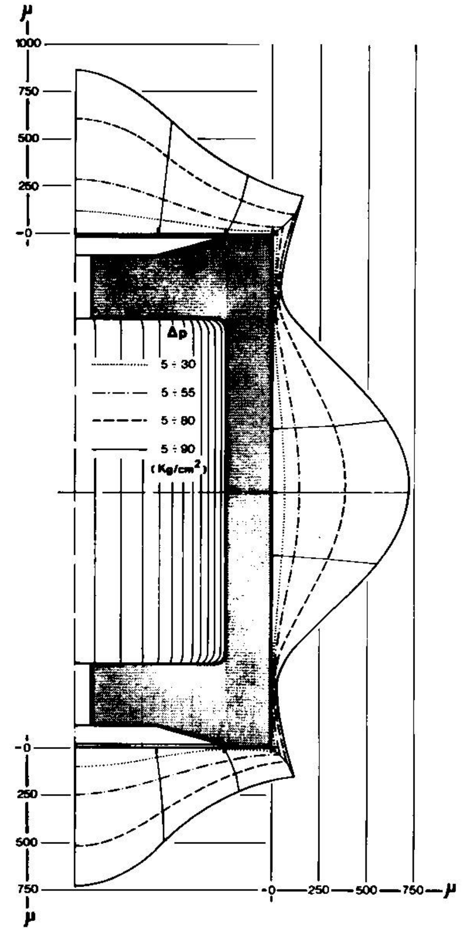


FIG. 10 DEFLECTIONS OF THE OUTSIDE SURFACE AT VARIOUS PRESSURE
DEPLACEMENTS DE LA SURFACE EXTERIEURE A DIFFERENTS NIVEAUX DE PRESSION
VERSCHIEBUNGEN FÜR VERSCHIEDENE DRUCKE

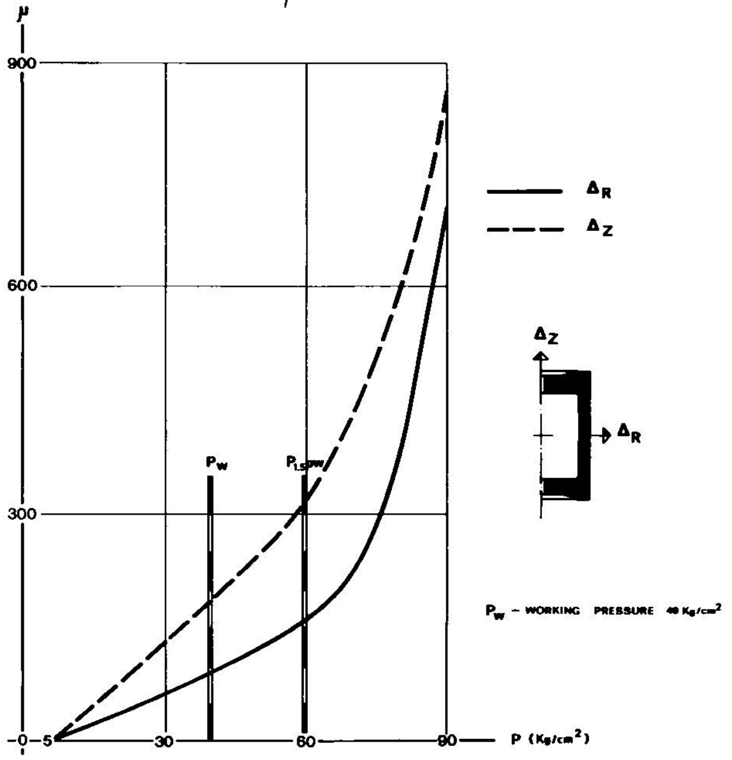


FIG. 11 TOP SLAB AND AEQUATOR DEFLECTIONS
DEPLACEMENTS AU POINT CENTRAL DE LA DALLE ET A L'EQUATEUR
VERSCHIEBUNGEN DES ÄEQUATORES UND DER DECKE

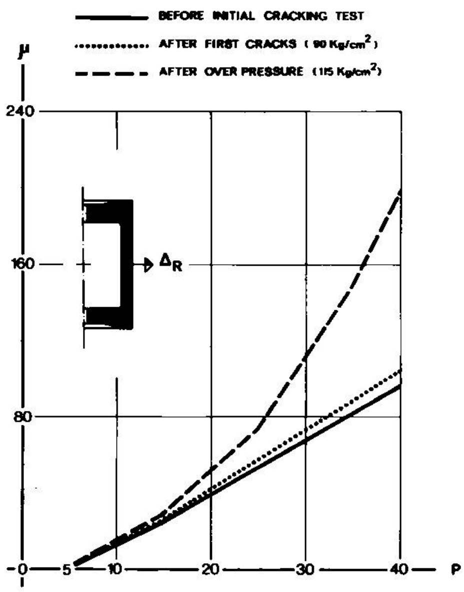


FIG. 12 AEQUATOR DEFLECTIONS AT WORKING PRESSURE
DEPLACEMENTS A L'EQUATEUR DANS LE DOMAINE DES PRESSIONS DE TRAVAIL
VERSCHIEBUNGEN DES ÄEQUATORES AND DEN DIENSTBEDINGUNGEN

OVERPRESSURE CYCLES AND COLLAPS TEST

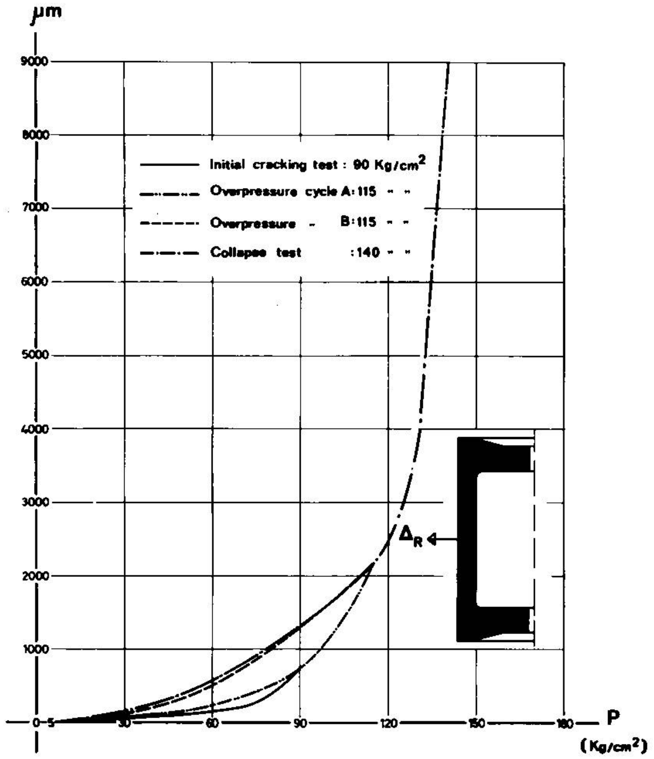


FIG. 13 AEQUATOR DEFLECTIONS
DEPLACEMENTS A L'EQUATEUR
VERSCHIEBUNGEN DES ÄEQUATORES

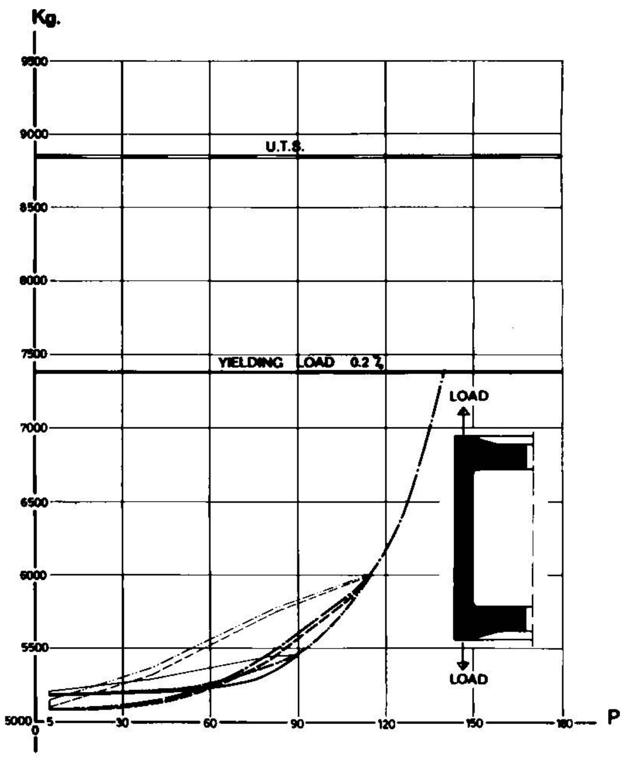


FIG. 14 VERTICAL CABLE ANCHORAGE LOADS
COMPORTEMENT DES CABLES DE PRECONTRAINTE VERTICALE
KRÄFTE IN DEN VERTICALENKABELN

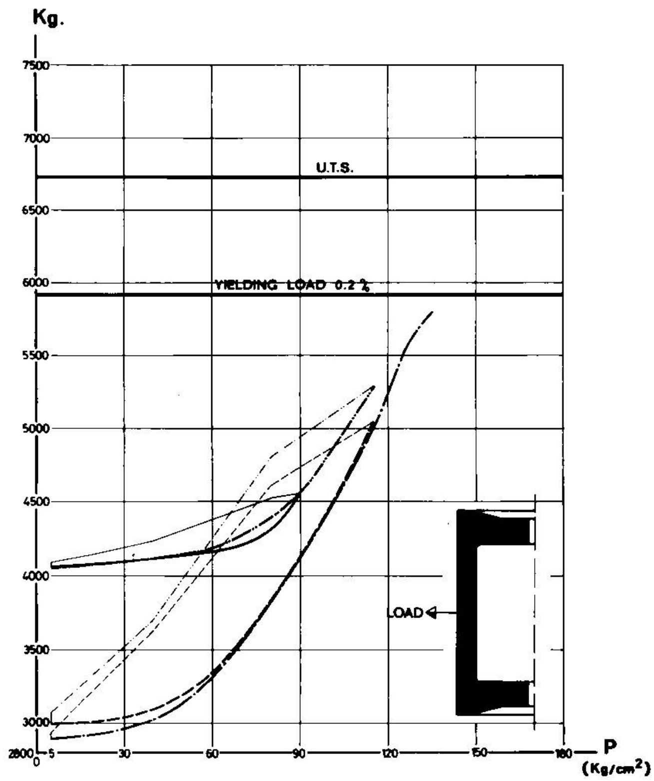


FIG. 15 HOOPING CABLE ANCHORAGE LOADS
COMPORTEMENT DES CABLES DE PRECONTRAINTE HORIZONTALE
KRÄFTE IN DEN KREISKABELN

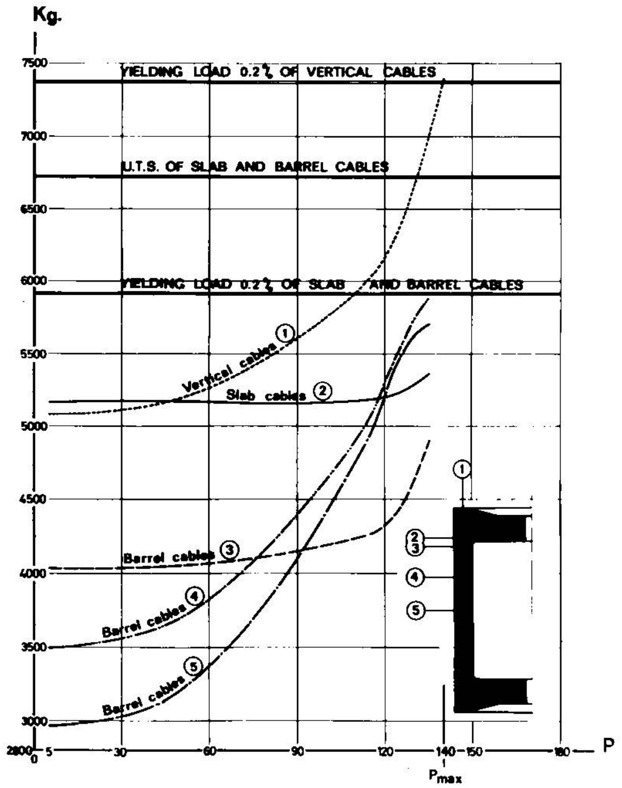


FIG. 16 COLLAPSE: CABLE ANCHORAGE LOAD
ESSAIS DE RUPTURE: COMPORTAMENT DES CABLES
KRÄFTE IN DEN KABELANKERN

As far as the hooping cables of the central band of the barrel are concerned, the considerations are analogous with the exception of the pulling decrease on the anchor heads (fig. 15). This decrease pull is probably due to a large extent to a more homogeneous load distribution along the cables, which in the prestressing stage it is not possible to obtain owing to the frictional effects.

5.2.4 In fig. 16 the average load increases in the collapse test of the vertical and hooping cables are shown. As can be seen, the hooping cables of the central band of the barrel almost reach the yield limit, whilst the load in the barrel hooping cables near the slabs increases considerably only in the final stage (more than 120 Kg/cm^2) mainly due to a process whereby the barrel and the end slabs tend to disconnect, as the rapid increase in the vertical cables load also suggests. The final collapse (140 Kg/cm^2) occurred with a complete failure collapse of the central part of the upper slab (fig. 17).

This type of unexpected failure (the previous model experienced the tendons failure) was due to the yield of the wires of the hooping of the cable system of the slab, whose diameter, unlike made for the wires of the other cable systems of this model (barrel hooping cables and vertical cables), had not been increased.

This means that the collapse mode can be driven by designers. For instance increasing the safety margins of the slab hooping cable system.it was possible to avoid the structural collapse of the slab itself.

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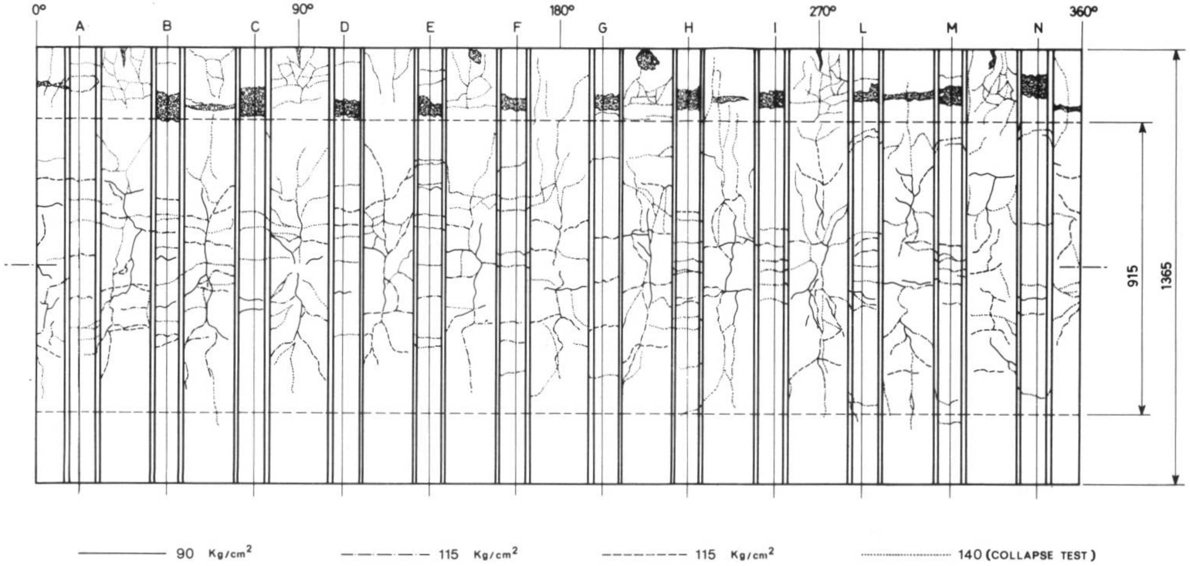
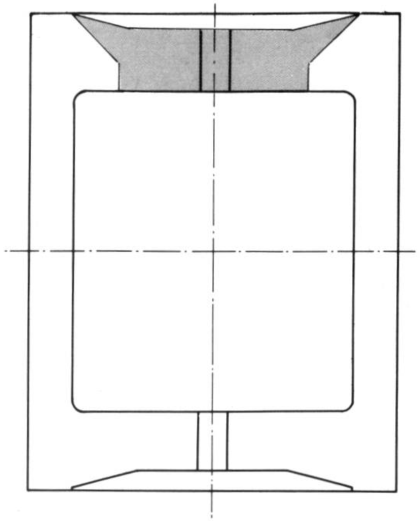
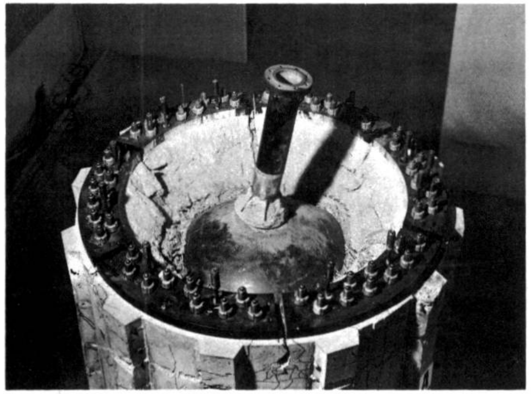
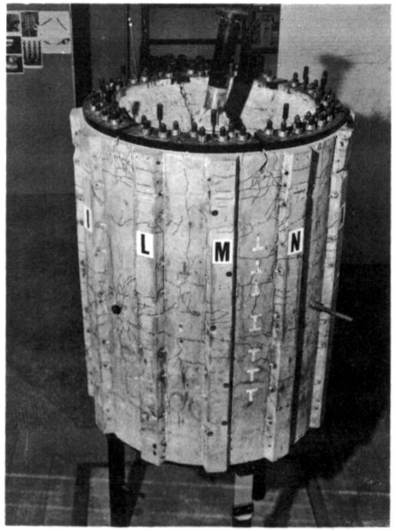
EXTERNAL SURFACE CRACK PATTERN



UPPER SLAB COLLAPSE AREA







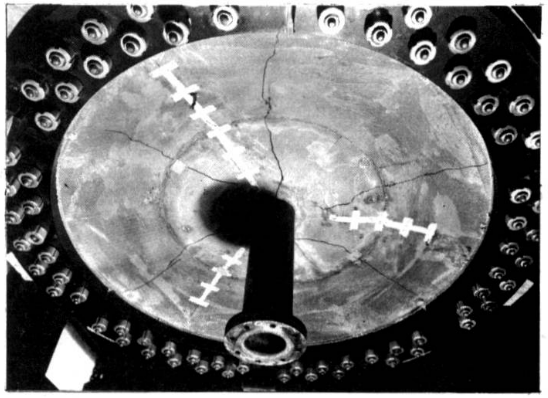


FIG. 17 MODEL AFTER COLLAPSE TEST
MODELE APRES L'ESSAI FINAL A RUPTURE
DER MODELL NACH DEN BRUCHVERSUCHEN
: 140 Kg/cm²

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SUMMARY

In this report the general principles ruling the models and static experimentation on prestressed concrete pressure vessels are described. Critical observations with regard to schematization principles adopted for models, testing methods and finally the reliability of the results are discussed.

The report deals with the testing techniques used at ISMES for three models of prestressed concrete pressure vessels with thin walls for "THTR" gas reactors.

The final part of the report describes more in detail the tests and results on the third model (CPS 3/3).

RESUME

Dans ce rapport on décrit les principes généraux qui règlent les modèles et l' expérimentation statique pour les caissons en béton précontraint. A ce propos, on développe des observations critiques sur les principes de la schématisation utilisée pour les modèles, les méthodes de essai et, enfin, la crédibilité des résultats obtenus.

Le rapport est accompagné d' une documentation sur les techniques d' expérimentation dévéloppées à l' ISMES pour trois modèles de caissons en béton précontraint avec parois minces pour réacteurs à gaz "THTR".

Enfin, on décrit - plus en détail - les essais et les résultats du troisième modèle (CPS 3/3).

ZUSAMMENFASSUNG

In diesem Bericht sind die algemeinen Richtlinien beschrieben, die bei der Ausführung von Modellen und statischen Versuchen über Behälter aus Spannbeton beachtet werden. In diesem Zusammenhang, werden kritischen Betrachtungen entwickelt über die für die Modelle angewandten Schematisierungs-Richtlinien, die Versuchsbedingungen und, zum Schluss, über die Glaubwürdigkeit der erreichten Ergebnisse.

Dem Bericht ist eine ausführliche Dokumentation beigelegt, über die Versuchstechniken, die ISMES für die Modelle eines dünnwandigen Behälters aus Spannbeton für "THTR" Typ-Reaktor (3 Modelle) angewandt hat. Im letzten Teil werden die Versuche und die Ergebnisse bezüglich des dritten Modelles (CPS 3/3) eingehender beschrieben.

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