Minutes of the Second Plenary Meeting of RILEM TC-TDC

Qingdao, 23-24 May 2013

Time	9:00-18:00, May 23, 2013 9:00-16:00, May 24, 2013
Venue	Room 1908, Scientific and Technical Building, Qingdao Technological University (QTECH), Qingdao
Main Subjects	**Task of Group A:** Proposal for the final version of the annotated bibliography **Tasks of Group B:** 1. Decision on the design of the test rigs for compressive and tensile load 2. Decision on test method. 3. Identification of labs participating in the comparative test series. 4. Selection of type of concrete.
Participants	21 persons all together attended the meeting, including: -- 14 members of TC-TDC: Prof. Yao Yan, Prof. F. H. Wittmann, Prof. Nele De Belie, Prof. Erik. Schlangen, Prof. Max Setzer, Prof. Zhao Tiejun, Prof. Wang Ling, Dr. Li Juan, Prof. Li Weihua, Prof. Jiang Fuxiang, Dr. Wu Hao, Prof. Wan Xiaomei, Dr. Wang Zhendi, Dr. Yang Jinbo. -- 1 from Shenzhen Univ. Dr. Dong Zhijun (Delegate of Shenzhen Univ.) -- 4 from CBMA: Tan Li (Director of the Foreign Affairs Office at CBMA), Zhou Chunying (Engineer of CBMA), Du Peng (PhD student in CBMA), Cao Yin (PhD student in CBMA). -- 2 from QTECH: Wang Penggang (PhD student in QTECH), Shang Jun (PhD student in QTECH).
Moderator	Prof. Yao Yan

1. Opening of the meeting

The Chairlady of TC-TDC, Prof. Yao Yan, welcomed at the beginning of the meeting all participants warmly. She briefly introduced herself and summarized the work that the members of RILEM TC-TDC have done in the past two years. The main task of Group A is to compile an annotated bibliography on durability of reinforced concrete under combined mechanical and environmental actions. On the occasion of the first plenary meeting of RILEM TC-TDC in Beijing, a first draft of the bibliography was discussed. After in-depth discussions the structure was slightly modified and a number of new papers were added. With the help of several TC members specific introductory remarks were prepared for each chapter to make the collection of relevant references a real “annotated” bibliography. The main task of Group B is to prepare a list of existing relevant test methods to characterize durability of concrete exposed to combined actions. A report on the achievements shall be published finally. During recent discussions members of TC-TDC came to an agreement to work on suitable test methods.

It is hoped that we can be finalize after in depth discusssions within Group A the annotated bibliography and that we will find an optimum solution for its publication and distribution. Then we have to decide on the final design of the test rigs and specify the concrete composition and the test procedure. Finally, as mentioned already Group A and Group B can be considered to be dissolved after this TC meeting as they have fulfilled their mission. The question arises if it will be reasonable to form new working groups for the second period of activities of our TC. We may for instance form one group, which concentrates on carbonation under the influence of mechanical load and another group, which concentrates on chloride penetration under the influence of mechanical load.

Prof. Zhao Tiejun, Vice-President of QTECH, also made a warm welcome speech and shortly introduced QTECH and Qingdao city.

Dr. Li Juan, on behalf of the Secretary of TC-TDC，gave a short overview on the main tasks of TC-TDC and main progress in the past one and a half years. She also introduced the website ***www.rilem.cn*** in detail. The aim of the website is to serve as an online platform for all members of TC-TDC, as well as a communicating channel of RILEM in China and across the world. It started running on March 1, 2012. Important informations about RILEM TC-TDC are permanently updated on the website, including informations concerning all members of TC-TDC, meetings, specific tasks, and so on. There is a Chinese item in the website, it is added following the request of Prof. De Schutter, the Development Director of RILEM. He suggested the Secretary of TC-TDC may translate some webpages of RILEM into Chinese. These informations are subdivided into six chapters: (a) About RILEM, (b) Mission of RILEM, (c) History of RILEM, (d) Organization, (e) Honors and awards and (f) How to join RILEM. The spcial Chinese section on ***www.rilem.cn*** is meant to serve as a window for Chinese colleagues to facilitate access to RILEM activities and to provide general information on RILEM.

2. Discussions and Conclusions of Group A

2.1 Introduction of the objectives, tasks and achievements of Group A

Prof. Folker H. Wittmann, Chairman of Group A, underlined that the main task of Group A is to publish an annotated bibliography containing complete references and summaries of all papers available in the literature in which results of studies to investigate durability of cement-based materials under combined actions are described. Then he introduced the structure of the content and details of procedure of publication of the bibliography.

Dr. Wang Zhendi, the secretary of Group A, made an introduction on the background, the main aim, progress made so far and still existing problems to be solved, such as 20 missing abstracts, missing introductory notes of Chapter 2 and Chapter 8 and so on. In Sep. 2011, during the inauguration meeting it was decided to prepare and finally publish a comprehensive annotated bibliography. From March 3rd, 2012, members of the TC-TDC were invited to send publications to the secretary, Dr. Wang Zhendi. On May 16th, 2012, members of the TC-TDC classified all papers collected. From Sep. 2nd, 2012, selected members of the TC-TDC started to add introductory remarks for each section and details of the publication procedure were fixed.

The main aim of this annotated bibliography is to serve as a reference book for those who are active in this field. It should be easy for all TC members at the first stage and for all colleagues who are active in this field or who want to start to work on similar topics. It is hoped that the annotated bibliography will help to provide easy access to the state-of-the-art to all our colleagues and to avoid unnecessary duplications. The selection criteria of the papers are based on the topic described and limited to common combinations.

2.2 Conclusions of Group A

1) The deadline for paper collection is May 31, 2013, that means soon after this meeting.

2) After discussions, a decision has been taken on the final structure of the document; see **Attachment 1**.

3) The format for the names of authors is as: Wittmann F. H. For Chinese names, the format for the names of authors is as: Wang Zhendi.

4) For the 20 missing abstracts, Prof. Nele De Belie suggested to circulate the list of all missing abstracts to all members, so that if someone who has a copy, he or she can the missing abbstract to the secretary Wang Zhendi.

5) Introductory notes are still missing for Chapter 2 and 8, and the secretary will contact Prof. Xing Feng and Prof. Weiss by email and ask them to submit their contribution within two weeks.

6) It was considered to be helpful to number the lines on all pages before distributing to all members. In this way corrections can be easily indicated.

7) The bibliography will be sent to all members as a pdf document, one month after having received all missing data for further and fiinal comments.

8) A CD with full papers will also be published together with the published bibliography. If the inclusion on the CD is not free of payment, only an internet link to the full length papers will be provided on the CD.

9) Prof. Wittmann will contact the RILEM Office to obtain agreement for the official publication of the bibliography.

3. Discussions and Conclusions of Group B

3.1 Introduction of the objectives, tasks and achievement of Group B

Chairlady of Group B, Prof. Wang Ling presented the objectives, tasks and achievements of Group B. The objectives of Group B are: (a) the collection and critical comparison of existing test methods, and (b) a proposal of a most promising test method for comparative test series. The actual tasks of Group B are to finish the compilation of the standards and recommendations for test methods, combination of environmental actions and mechanical load and selection of the most promising test methods and characterization parameters.

For the compilation of standards & recommendations for test methods, Prof. Wang Ling informed the committee members that Group B collected 46 test methods and standards related to concrete durability before the first plenary meeting in Beijing last year, mainly Chinese standards (GB) and European standards. After that, more than 10 ASTM standards and CEN standards were collected. Participants of group B provided a lot of test methods used in their countries to test concrete durability under one single environmental factor, such as freeze-thaw cycles, carbonation, AAR, leaching or chloride penetration. It was found that even test methods of concrete durability under the same environmental actions differ a lot. The draft compilation of standardized test methods prepared for this meeting consists of 7 test procedures for carbonation, 5 for frost damage and 7 for chloride penetration. But there are no standards and recommendations for testing durability of concrete under combined actions so far. Some members summarized their own test methods used in research projects to study the behavior of concrete durability under combined actions, such as mechanical load, freeze-thaw cycles, carbonation, and chloride penetration. Experts all over the world carried out tests under different load combinations. Many projects were focused on the influence of stress level on the concrete durability, but the critical stress threshold btained varied a lot due to the differences of test devices, concentration of chloride solution and dimension of specimens. So, there is a real need to establish a unified test method, which will allw us to determine durability of concrete under combined actions in order to be able to predict the corresponding service life of reinforced concrete structures in aggressive environment..

It turned out that the selection of the most suitable test methods for studying the effect of combinations of environmental actions and mechanical load is really very difficult. During the Cape Town meeting, we came to the conclusion that TC-TDC should focus on the following two types of combinations: (a) axial compression and tension combined with chloride penetration and (b) axial compression and tension combined with carbonation. Test rigs for these four types of combinations were designed and a prototype was manufactured. Prof. Wang Ling hopes that the TC members will agree on these proposals and then the first round of comparative test series can start as soon as possible. The test rigs were co-designed by Prof. Yao Yan, Prof. F. H. Wittmann, and Dr. Wang Zhendi. Prof. Erik Schlangen provided valuable suggestions for details of the design.

Prof. Wang Ling introduced the basic principles of the test rigs: (1) The most important requirement for a standard test, which ought to be run in as many laboratories as possible, is simplicity of the test. Many standard laboratories from different parts of the worlds should be able to run such a test following a RILEM recommendation. (2) The test results should be applicable directly to quantify the influence of a given applied load on service life of reinforced concrete structures under given environmental conditions.

For more detailed description of the test rigs, please see **Attachment 2.**

3.2 Conclusion of Group B

3.2.1 Test Rigs

After an intensive discussion, **the following modifications of the test rig for compressive load were suggested:**

1) The dimension of the specimens should be fixed to be 100 x 100 x 400 mm.

2) Screw nut should be used rather than hydraulic equipment for loading.

3) Adding a movable ball bearing on the top.

4) Using 4 steel bars (as thin as possible) instead of 2, pasting 4 strain gauges on the 4 tensile bars.

The following modifications of the test rig for tensile load were suggested:

1) Adding a cover to the two end sides of the mould to prevent fresh concrete come into the box.

2) The dumbbell shaped specimens shall have a square section in the centre, and the dimensions of the part with square section shall be: 100 x 100 x 200 mm^3.

3) 4 screw bolts of one pull head should not be put in line, It is suggested to place them at each corner (better distribution of stresses).

4) Using ball hinges instead of hinge units.

5) Dr. Dong Zhijun will calculate the maximum stress in the steel bars and provide us with the results within 3 weeks to see if there is a need for further modifications.

6) Five strain gauges are needed for 4 compressive bars and a tensile bar above the hinge. It is decided that the indication of tensile strain gauge is the reference value.

3.2.2 Final decisions with respect to test methods

See **Attachment 3**.

3.2.3 Identification of laboratories, which may participate in the comparative test series

First, Mr. Cao Yin, a PhD student in CBMA, introduced the State Key Laboratory of Green Building Materials of CBMA. Next, some of the delegates from other labs introduced their labs and showed their interest to participate in the comparative test series. Finally, the result of the inquiry among the TC members present in Qingdao on the availability of diffeerent labortories is shown in the following Table I:

Table I: Laboratories, which are prepared to join the comparative test series

No.	Member	Affiliation	Carbonation + load	Chloride + load
1	YAO Yan	CBMA	Y	Y
2	ZHAO Tiejun	Qingdao Tech. Univ.	Y	Y
3	XING Feng	Shenzhen University	Y	Y
4	LI Weihua	Institute of Oceanology, Chinese Academy of Science	N	Y
5	DE BELIE Nele	Ghent Univ.	Y	Y
6	SCHLANGEN Erik	Delft Univ. of Technology	Y	Y

Prof. Glinicki sent an email to express his interest to participate in the forthcoming comparative tests on May 25. In addition, several colleagues were recommended because of their existing research experience and test facilities. The secretary will invite several TC members officially to join the comparative test program, such as Prof. Tamon UEDA from Hokkaido Univ., Prof. Carmen ANDRADE from the National Research Council of Spain, Prof. Christoph GEHLEN from Munich University of Technology. Hopefully even more laboatories will join the comparative test series. If more laboratories participate the results may become more reliable.

3.2.4 Selection of type of concrete.

The mix proportion of concrete for the calibration test series (zero series) before the first round of comparative test series was decided to be as shown in Table II:

Table II: Composition of concrete for zero test series

Cement kg/m^3	w/c	Water kg/m^3	Fine aggregate kg/m^3	Coarse aggregate kg/m^3	Superplasticizer kg/m^3	Slump cm
368	0.45	165.5	840	1027.5	5.1	12~15

4 Closing remarks by the chairlady, Prof. Yao Yan

The meeting was closed at 16:00 p.m. on May 24th in the afternoon. In the wrap-up presentation, Prof. Yao Yan expressed her sincere thanks to Prof. Folker H. Wittmann, who has volunteered to be the Chairman of Group A and has given TC-TDC a lot of guidance, and to Prof. Wang Ling for her continuing engagement to make this meeting meaningful and successful, and to Prof. Erik Schlangen who provided valuable ideas for a promising design of the test rigs. Then she offered her sincere thanks to Prof. Zhao Tiejun for hosting and supporting this meeting. She also thanked all the experts who attended the meeting for their personal efforts and their support for the RILEM TC-TDC, and those who were unable to attend the meeting but helped a lot in sending TC-TDC their publications and regionally applied test methods. She looked forward to the future co-operation with all our TC members.

At last, she suggested having a short informal meeting of RILEM TC-TDC in Paris during the first week of September 2013. That would be a good chance to discuss results of the zero test series, which ought to be run before the first official round of comparative tests and share the experiences and achievements with other RILEM members who could not come to Qingdao.

Before the meeting was closed, she expressed her hope that everyone would enjoy himself or herself in Qingdao after this meeting. She also invited everyone to visit CBMA before or after the International Symposium on Cement and Concrete (ICCC2013) held in Nanjing this September.

She concluded that herself and all members present were confident that the ambitious aim of TC-TDC will be achieved finally.

Post TC meeting ad hoc Seminar and laboratory tour

After the meeting, Prof. Jiang Fuxiang and Wang Penggang, both from QTECH, presented in an ad hoc seminar their research work on concrete durability under combined actions. All TC – TDC members had the opportunity to discuss the state-of-the-art in this field. All participants visited later the laboratories of QTECH in which relevant tests are run.

Some participants took part in a short excusion to visit the new Qingdao Jiaozhou Bay Subsea Tunnel and the Jiaozhou Bay Bridge, which is at this moment the longest bridge in the world.

Attachment 1: Annotated Bibliography, Table of Content

Contents

Attachment 2 –Brief Description of Test Rigs

1 Introduction of the test rig for compression

The test rig for application of a ccompressive load is introduced by Prof. Wang Ling (with regards to the corresponding drawing of the compressive model, please see **attachment 2-A**), Information on the prototype, main elements, role of the disc springs, concrete specimen and operation were presented. The dimension of the test rig is 60.5 cm in height, 22 cm in width and 6.5 cm in thickness; its net weight and gross weight are 18.4 kg, and 28.0 kg, respectively (gross weight means with 1 concrete specimen 10 x 10 x 40 cm). Between the top board and the middle board of the test rig, 40 disc springs are placed for energy storage. These springs are used to compensate creep deformation of concrete and keep the applied laod approximately constant. A concrete specimen is placed between the middle board and the base board of the test rig vertically.

It is foreseen that the test rig is placed on a testing machine in order to apply a predetermined compressive load. The load should be increased until the reading of the strain gauges which are fixed on two opposite sides of the concrete specimens reaches the targeted value or until the reading of the compressive stress shown by the testing machine reaches the preset value. Then the further increase of lad is stopped and the screw nuts on both sides are tightened quickly. As the disc spring is compressed to a certain extent, the displayed load of the testing machine will drop to 0. Then the test rig can be taken away from the hydraulic machine. Concrete specimens under constant predetermined load are thus ready for either chloride penetration or carbonation.

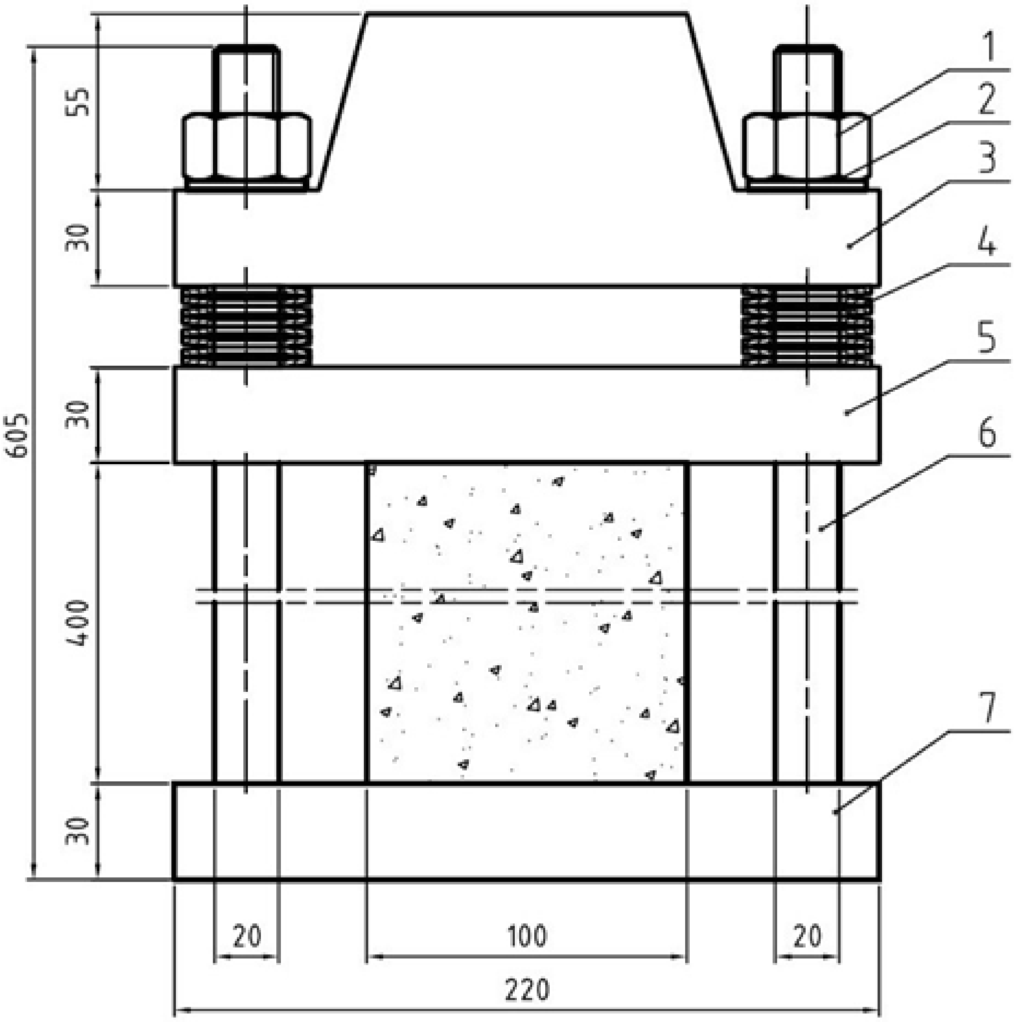
2 Introduction of the test rig for tension

The test rig for application of axial tension is not easy to design due to the common eccentricity. A few creative ideas have been adopted in the design of the test rig to ensure the applied tensile stress on the specimen is always along the axial direction. The test rig for tensile loading is also introduced by Prof. Wang Ling. Information on the prototype, specimen molding, main elements, role of hinges, role of a square hole in the middle plate, concrete specimen and operation were presented. (For further details see **attachment 2-B**)

A special mould for the dumbbell specimen was designed (See **attachment 2-C**). 4 location tubes were welded on each of the two short frames, strictly perpendicular to the plane formed by the short frames. Screw bolts are placed in the location tubes before concrete is cast into the mould. Pull heads with 4 holes can be perfectly secured on the concrete specimens through the 4 embedded screw bolts on each side. There is another hole of 16 mm diameter in the middle of each pull head through which the concrete specimen can be connected with the test rigs. The screw nut with thrust bearing to apply the tensile load is at the highest point. 44 disc spring of 31.5*16.3*1.25*0.9 mm are stacked together in use. There are 2 identical hinge units loacated in the lower side and the upper side. The upper hinge unit is fixed on the middle compressive plate through the pop rivet and linked to the upper pull head through the articulated pin. The lower hinge unit is fixed on the base board through a screw and fixed on the lower pull head through the articulated pin. The two pins of the above hinge units are placed in perpendicular directions to eliminate the axial eccentric. When tightening of screw bolts, horizontal turning of the hinge unit on the top may occour. To avoid the occurrence of torque to the specimen, a square hole with the demision of 16.5 x 16.5 mm in the middle plate were applied , which locks deadly with the square portion of the pop rivetto prevent the revolve.. The center zone with a constant width of the dumbbell specimen is 17.5 cm long, 10 cm wide and 5 cm depth thickness. This zone is enough for the determination of chloride coefficient and carbonation.

The concrete specimen is assembled in the test rig through the two hinge units. While tightening the screw nuts in the highest point, the disc springs are compressed and the pop rivet is subjected to the pulling-up force. The tensile load is passed onto the concrete specimen through the hinge units. Continuely to tighten the screws on the top of the test rig until the reading of the strain gauge which affixed to the side of the concrete specimen reaches the preset value. Now the concrete specimen under constent tensile load is ready for either chloride penetration experiments or carbonation experiments.

Attachment 2-A :Assembly drawing of test rig for compressive load



NO.	Code	Name	Materials	Quantity		
7	CM01-07	Base board	45#	1		
6	CM01-06	Threaded rod		2		
5	CM01-05	Middle board		1		
4	CM01-04	Disc spring 40x20.4x1.5		40		
3	CM01-03	Top board	45#	1		
2	GB95-85-20	Gasket		1		
1	GB/T1229-91M20	Nut		1		

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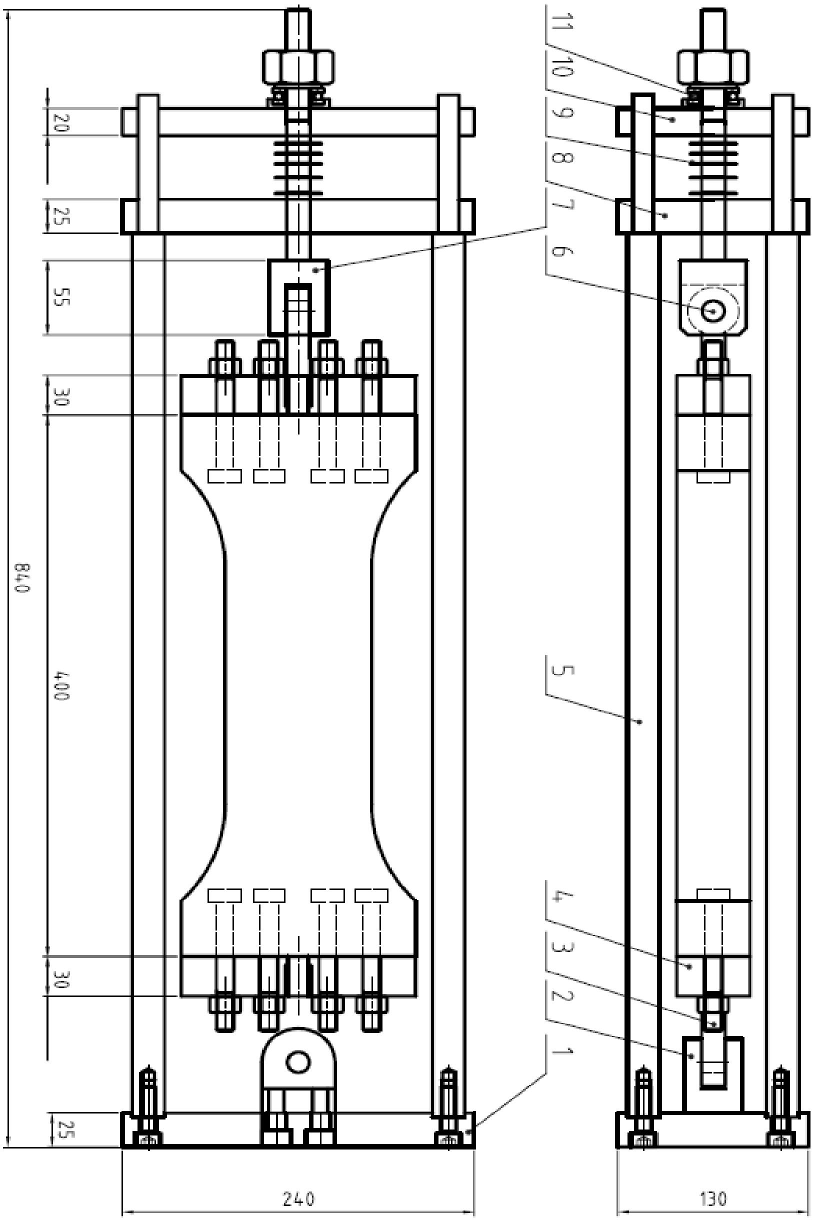
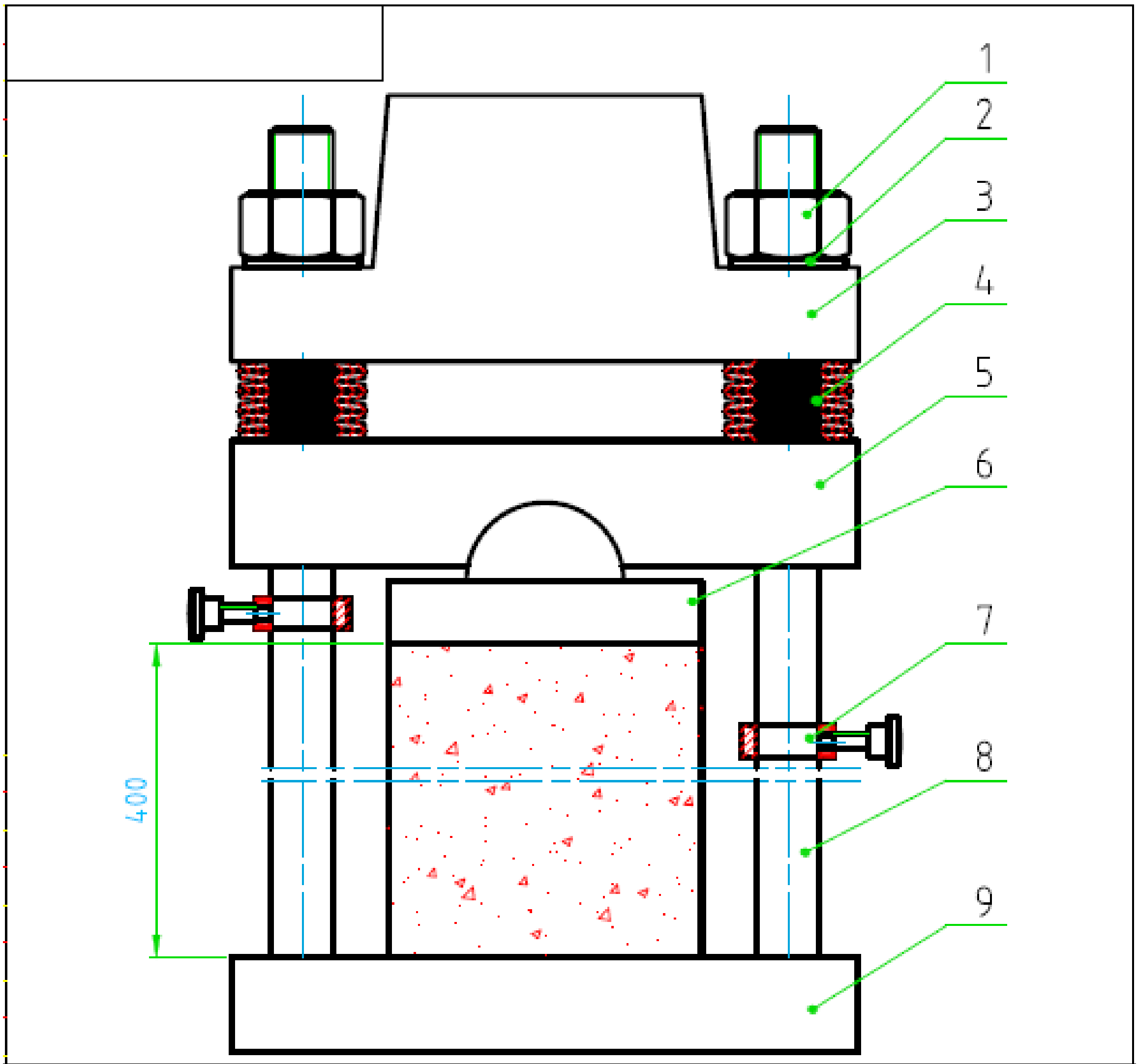
Attachment 2-B: Assembly drawing of test rig for tensile load



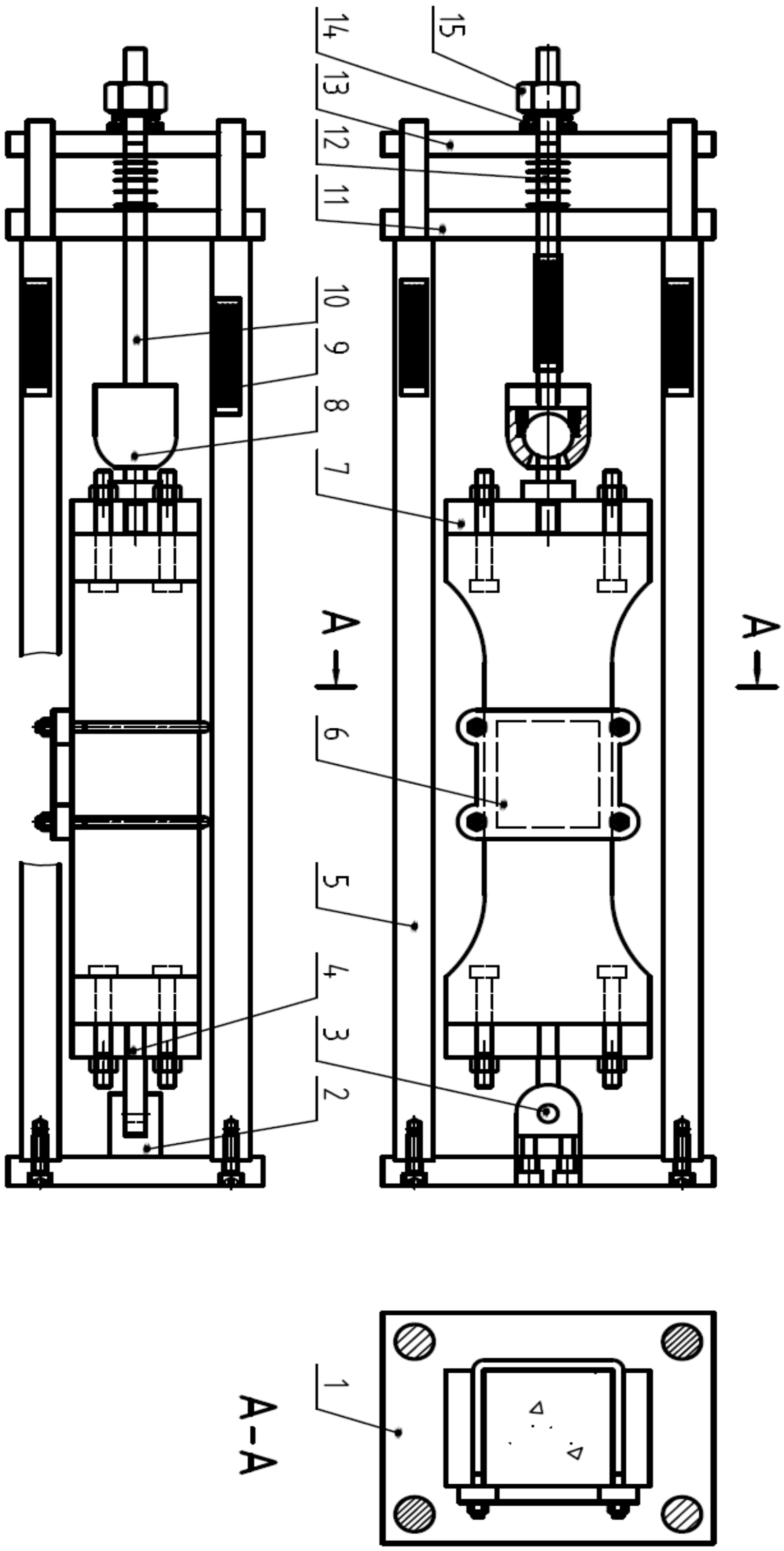
11	CM02-11	Thrust bearing	1	51104			
10	CM02-10	Up-plate	1	45#			
9	CM02-09	Disc spring31.5X16.3X1.25	44	31.5X16.3X1.25			
8	CM02-08	Middle compressive plate	1	45#			
7	CM02-07	Pop-rivet	1	45#			
6	CM02-06	Hinge pin	2	45#			
5	CM02-05	Stand column	4	45#			
4	CM02-04	Pull head	2	45#			
3	CM02-03	Articulated pin	2	45#			
2	CM02-02	Base	1	45#			
1	CM02-01	Baseboard	1	45#			
NO.	Code	Name	Quantity	Materials			Note

Attachment 2-A-R : Revised Assembly drawing of test rig for compressive load

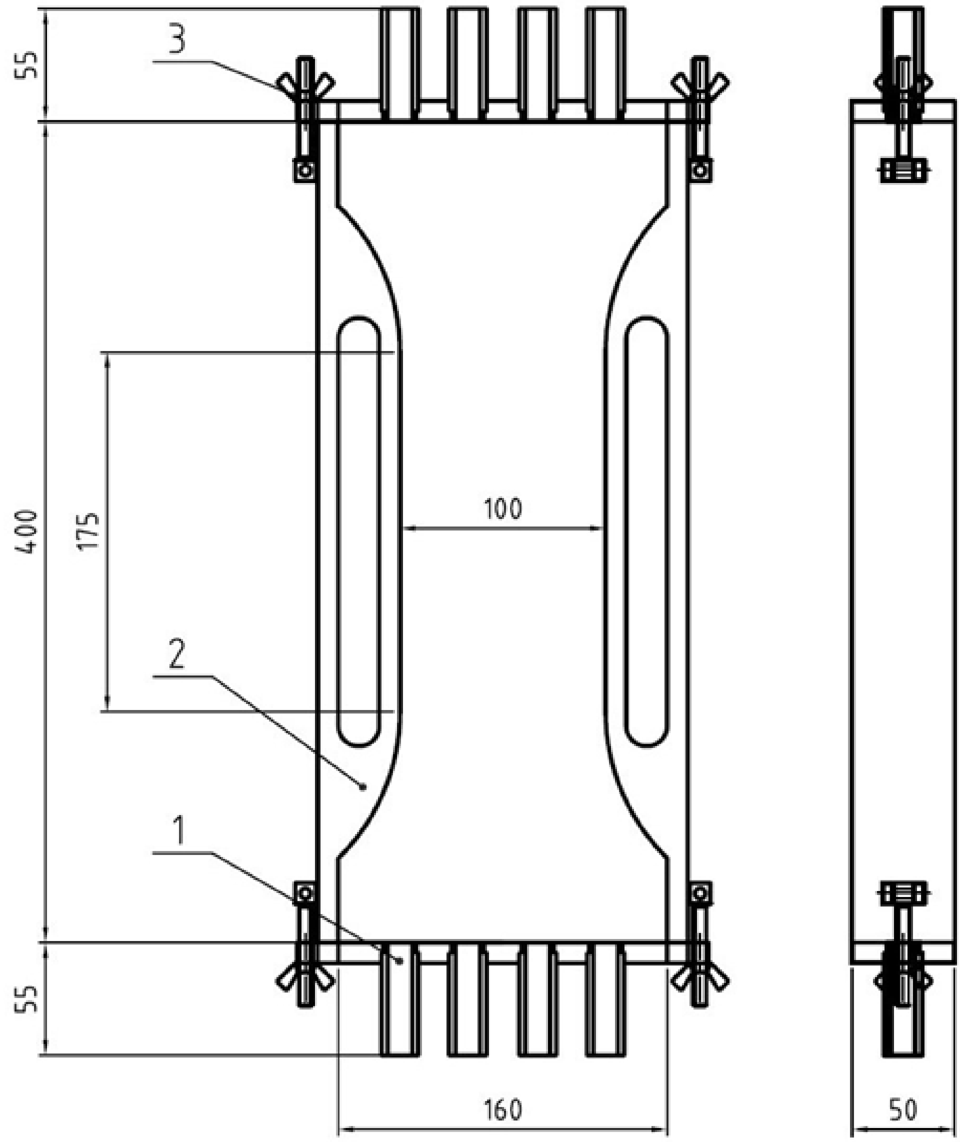


NO.	Code	Name	Qua	Materials		Wei.	Remarks
9	CM02-09	Base Board	1	45#			
8	CM02-08	Tension Bar	4	45#			
7	CM02-07	Limited Block	4	Q235A			[illegible]
6	CM02-06	Spherical Bearing Plate	1	45#			
5	CM02-05	Bearing Plate	1	45#			
4	CM02-04	Disc spring	80	40X20.4X1.5			
3	CM02-03	Upper Bearing Plate	1	45#			
2	GB95-85	Gasket	4	ø20			[illegible]
1	GB/T1229-91	Nut	4	M20			High Str.

Attachment 2-B-R: Revised Assembly drawing of test rig for tensile load



Attachment 2-C: Drawing of mould for durability test of concrete under tensile load



No.	Code	Name	Quantity	Materials			
3	CXMJ01-03	Wing nut	4	M6			
2	CXMJ01.02	Long frame	2	Weld			
1	CXMJ01.01	Short-frame	2	Weld			

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Attachment 3: Proposed Test Method

A detailed description of the comparative test method was made by Prof. Wang Ling. She had checked some published RILEM recommendations. RILEM recommendation published earlier usually consist of 10 parts: (1) Scope and Applications, (2) Equipment, (3) Consumable Materials, (4) Materials and Mix Design, (5) Preparation of Test Samples, (6) Measurement Procedure, (7) Expression of Test Results, (8) Damage Criteria, (9) Report (10) Alternative Tests.

It is not easy to fulfill requirements of all 10 sections. Some indiccations were given, others shall have too be formulated later.

After long discussion followed and some decisions were made:

1. Scope and applications

TC-TDC focuses on the following four types of combinations of applied mechanical stress and environmental actions: (a) Direct applied compressive and tensile stress combined with chloride penetration, (b) Direct applied compressive and tensile stress combined with carbonation.

2. Test rigs

The test rigs were designed and prepared based on the outcome of the literature review and achievements developed by TC-TDC members. Laboratories, which have the same test rigs can use their own equipment. For those who donot have similar test rigs so far, it is strongly recommending to use test rigs as designed by TC-TDC and carry out the tests following precise indications.

3. Determination of chloride profiles

3.1 Diffusion test on saturated specimens

1) Specimens have to be prepared without de-moulding agent during casting, compact the fresh concrete in the appropriate forms, then cover the surface with plastic sheet for 24 hours.

2) Put all specimens in water (saturated $Ca(OH)_2$ solution) and cure them at 20 °C until an age of 28 days is reached. Determine gain of water during curing.

3) Specimens which will be cured in a moist chamber shall be covered with plastic sheet for 24 hrs, then cured in a moist chamber (RH $\geqslant$ 95 %, T = 20$\pm$2 °C) until an age of 28 days. Determine loss of water during curing.

4) - Specimens cured in water: take the specimens out of water and remove the free water from the surface with a dry cloth, then seal the surface with self-adhesive aluminum foil, just leave an open window (80 x 160 mm) on a moulded surface where the salt solution tank shall be fixed. Determine capillary absorption on cubes prepared with the same type of concrete and stored under identical conditions.

- Specimens cured in a moist chamber: Wrap the specimens with self-adhesive aluminum foil, leave one window open for the sultion tank. Determine capillary absorption on cubes prepared with the same type of concrete and stored under identical conditions.

5) Circulate the 3 % salt solution with a pre-defined speed (l/s), and then apply the pre-defined load levels.

6) Run all tests in duplicate.

7) Determine the chloride profiles after 2, 6, 18 and 54 weeks of exposure.

8) Determine the diffusion coefficient of chloride.

3.2 Migration test on pre-dried specimen

1) Dry the specimen after 28 days curing in water, dry at 50 °C in an aerated oven for 5 days, determine the loss of water by weighing.

2) Seal the specimen with self-adhesive aluminum foil. Open a window (80*160 mm) on a moulded surface where to fix later the salt solution tank and the same window on the opposite side.

3) Close the window temporarily with non-adhesive aluminum foil and allow re-distribution of moisture content for 4 weeks at room temperature.

4) Determine capillary absorption on cubes prepared with the same type of concrete and stored under identical conditions.

5) Fix a tank with dimensions 80*160*50 mm link it with a reservoir containing about 25 liters of salt solution or sea water.

6) Circulate the 3% salt solution with a pre-defined speed (l/s), and then apply the pre-defined load.

7) Determine the chloride profile after 2, 6, 18 and 54 weeks

8) Run all tests in duplicate

9) If time allows, the same test should be run with aqueous salt solution and seawater in the tank.

3.3 Chloride profile

1) Determine the chloride profile either by milling layers of 1 to 2 mm thickness or by cutting slices of 3 to 5 mm thickness and grinding the slices in a ball mill.

2) At least 8 layers parallel to the surface, which was exposed to the salt solution, shall be removed from the samples in order to determine the profiles of penetrated chloride.

3) Determine the water soluble and total chloride content by chemical analysis.

4.) Deetermine the diffusion coefficient of chloride

5) Results shall be compiled and discussed.

3.4 Task separation as followed:

	Saturated		**Pre-dried**	
	Compression	**Tension**	**Compression**	**Tension**
CBMA	Y	Y	Y	Y
QTECH	Y	Y		
OI-CSA	Y			
Delft Univ. of Technology	Y	Y		
Ghent Univ.	Y		Y	

4. Determination of carbonate profiles

4.1 Preparation of specimen

1) Dry the specimens after 28 days curing in water, then dry them at 50 °C in an aerated oven until constant weight; determine the loss of water by weighing.

2) Seal two opposite sides (formed surfaces) of the specimen with self-adhesive aluminum foil, and leave the finished and the bottom surface free.

3) Expose the specimens to 4±1 % CO_2 atmosphere (RH = 65 %, 20 °C), and then apply the pre-defined load

4) Determine the CO_2 profile after 20 and 40 weeks

5) Run all tests in duplicate.

4.2 Carbonate profile

1) Determine the carbonation profile by milling thin layers from the surface or cutting slices as described for the determination of chloride profiles.

2) Determine the $CaCO_3$ by chemical analysis or with the calibrated pressure gauge.

3) Determine carbonation profiles in the laboratory atmosphere (RH = 60 %, 20 °C) in parallel, and determine the acceleration factor.

4.3 Task separation as followed

	Lab curing		**Pre-dried**	
	Compression	**Tension**	**Compression**	**Tension**
CBMA			Y	Y
QTECH			Y	Y
Shenzhen Univ.	Y	Y	Y	Y

5. Materials and mix design

The composition of the concrete for the preliminary test series (zero test series) shall be as follows:

Cement kg/m^3	**w/c**	**Water kg/m^3**	**Fine aggregate kg/m^3**	**Coarse aggregate kg/m^3**	**Superplasticizer kg/m^3**	**Slump cm**
368	0.45	165.5	840	1027.5	5.1	12 to 15

6. Load level

All tests shall be run with under constant compressive or tensile stress.

The load levels (applied stress related to ultimate stress) under compression are fixed to be 0, 30 and 60 % (minimum 3 levels, 40 %, 50 % can be run in addition).

The load levels under tension are fixed to be 50 and 80 % (minimum of 2 levels, 30 % and 65 % can be run in addition).