



7th Framework Programme

FP7-SEC-2012.4.3-1

**Next Generation Damage and Post-Crisis Needs Assessment Tool for
Reconstruction and Recovery Planning
Capability Project**

Results of Component Testing

Deliverable No.	D7.1		
Workpackage No.	WP7	Workpackage Title	System Evaluation
Author(s)	Roger Berglund, Anneli Ehlerding, Björn Gregorsson, Tobias Carlberg, Håkan Hansson (FOI)		
Status	Final		
Version No.	V1.00		
File Name	"RECONASS_D7.1_Results_of_component_testing_v1.00"		
Delivery Date	30 09, 2015		
Project First Start and Duration	Dec. 1, 2013; 42 months		



"This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no [312718]"

DOCUMENT CONTROL PAGE

Title	Results of Component Testing	
Authors	Name	Partner
	Roger Berglund	FOI
	Anneli Ehlerding	FOI
	Björn Gregorsson	FOI
	Tobias Carlberg	FOI
	Håkan Hansson	FOI
Contributors	Name	Partner
	Bastian Lindner	TUD
	Niko Joram	TUD
	Jonathan Naundrup	GeoSig
	Isaiah Saibu	GeoSig
	Sathish Nammi	ARU
	Hassan Shirvani	ARU
Peer Reviewers	Name	Partner
	Corrado Sanna	TECNIC
	Dimitris Bairaktaris	DBA
Format	Text-MS Word	
Language	en-UK	
Work Package	WP7	
Deliverable Number	D7.1	
Due Date of Delivery	30/09/2015	
Actual Date of Delivery	30/09/2015	
Dissemination Level	PP	
Rights	RECONASS Consortium	
Audience	<input type="checkbox"/> public <input checked="" type="checkbox"/> restricted <input type="checkbox"/> internal	
Revision	(none)	
Edited by		
Status	<input type="checkbox"/> draft <input checked="" type="checkbox"/> Consortium reviewed <input checked="" type="checkbox"/> WP leader accepted <input checked="" type="checkbox"/> Project coordinator accepted	

REVISION LOG

Version	Date	Reason	Name and Company
V 0.01	11/09/2015	First draft	Roger Berglund (FOI)
V0.02	15/09/2015	Second draft – Contributions by GS, ARU, TUD	Bastian Lindner (TUD), Niko Joram (TUD) Jonathan Naundrup (GS), Isaiah Saibu (GS) Sathish Nammi (ARU), Hassan Shirvani (ARU)
V 0.03	28/09/2015	Draft finalisations * Peer reviewed by TECNIC and DBA	Roger Berglund (FOI)
V1.00	30/09/2015	PC & QM Review	Evangelos Sdongos (ICCS), Stephanos Camarinopoulos (RISA)

TABLE OF CONTENTS

DOCUMENT CONTROL PAGE	2
REVISION LOG	3
TABLE OF CONTENTS	4
LIST OF FIGURES	6
LIST OF TABLES	8
ABBREVIATIONS AND ACRONYMS	9
EXECUTIVE SUMMARY	10
1 INTRODUCTION	11
1.1 GENERAL PROJECT OVERVIEW	11
1.2 COMPONENT TESTS	11
2 EXPERIMENTAL SETUP	12
2.1 STRUCTURE 1 – SLAB	12
2.1.1 Setup and manufacturing of slab.....	12
2.1.2 Gauges and instrumentation	14
2.1.3 Video coverage	18
2.1.4 High Explosive Charges	18
2.1.5 Test programme	19
2.2 STRUCTURE 2 – FRAME	20
2.2.1 Setup and manufacturing of frame	20
2.2.2 Gauges and instrumentation	21
2.2.3 Video coverage	25
2.2.4 High Explosive Charges	26
2.2.5 Test Programme.....	26
3. RESULT AND DISCUSSION	28
3.1 SLAB TESTS.....	28
3.2 FRAME TESTS	32
CONCLUSIONS	37
REFERENCES	38

ANNEX/ES 39

A.1 SLAB TESTS 39

 A.1.1 Slab 1 39

 A.1.2 Slab 2 46

 A.1.3 Slab 3 53

 A.1.4 Slab 4 60

A.2 FRAMES TESTS 66

 A.2.1 Frame 1 66

 A.2.2 Frame 2 75

LIST OF FIGURES

Figure 2.1	Layout of slab positioning on concrete supports and charge arrangement.....	12
Figure 2.2	Fully instrumented slab with charge ready above.....	13
Figure 2.3	Layout of the slabs with rebars and gauge locations. (P1 and P2 refer to pressure gauges, A1 and A2 refer to acceleration gauges, and S1-S6 refer to strain gauges.).....	14
Figure 2.4	Detail of how to fix the slab against the supports.....	14
Figure 2.5	Casting was done for all four slabs at the same time.....	14
Figure 2.6	Strain gauges mounted on the reinforcement bars.....	14
Figure 2.7	Overview of the cabling for the strain gauges.....	15
Figure 2.8	To the left an aluminium cylinder for fixing the accelerometer seen from behind before casting and to the right from the underside just before test.....	15
Figure 2.9	Position of pressure (P) and accelerometer (A) gauges.....	15
Figure 2.10	A laser distance gauge under the slab. The red dot is the measuring point. The accelerometer and the cable coming from the pressure gauge is also seen in the picture.....	16
Figure 2.11	Slab fixed to concrete supports with laser distance gauges underneath.....	16
Figure 2.12	Still images from the three different high speed videos. To the left the Photron, then the GoPro in the middle and to the right the Casio.....	18
Figure 2.13	The cylindrical charge hanging above the slab. The red wire is the tube for the Nonel ignitor.....	18
Figure 2.14	A frame ready for testing with charge on left.....	20
Figure 2.15	Layout of the frames with rebars and all gauge locations. (P1 – P5 refer to pressure gauges, A1 and A2 refer acceleration gauges, D1 and D2 refer to deformation gauges, and S1-S6 refer to strain gauges).....	21
Figure 2.16	The frame before mounting gauges and side covering.....	21
Figure 2.17	Position of pressure (P) and accelerometer (A) gauges on the front and the backside (right picture).....	22
Figure 2.18	Position of pressure gauge on top.....	22
Figure 2.19	The front side of the frame with three of the pressure gauges, P1-P3.....	23
Figure 2.20	Laser distance gauge D1, accelerometer A1, cable from pressure gauge P2 and the long threaded bolts for fixing the frame to the ground.....	23
Figure 2.21	Position of TUD and GeoSig instrumentation.....	24
Figure 2.22	Frame1 with instrumentation to the left and frame 2 to the right.....	24
Figure 2.23	Still images from the three different high speed videos. To the left the Photron, then the GoPro in the middle and to the right the Casio.....	26
Figure 2.24	Charge hanging in rack in front.....	26
Figure 3.1	Location of the pressure gauges (P) on the slab tests.....	28
Figure 3.2	Acceleration (A) and displacement (D) measurements under the slab.....	29
Figure 3.3	Post-test photo of the reinforced concrete slabs, a) slab No. 1, 2.0 kg HE, b-c) slabs No. 2 and 4, 3.6 kg HE, d) slab No. 3, 4.8 kg HE.....	30
Figure 3.4	Location of the strain gauges (S) in the slab tests.....	31
Figure 3.5	Location of the pressure gauges on the frame tests, P1-P6.....	32
Figure 3.6	Acceleration and displacement measurements on the frame.....	33
Figure 3.7	Location of the strain gauges, S1-S10, in the frame tests.....	34
Figure 3.8	Blast resistant steel casing before and after the blast.....	35
Figure 3.9	LPS after the blast.....	35
Figure 3.10	Mechanical fixation of sensor housing for accelerometers.....	36
Figure A.1	Pressure and impulse density from slab 1 test.....	39
Figure A.2	Acceleration on slab 1 test during the first 5 ms.....	40
Figure A.3	Displacement calculated from the acceleration of slab 1 test.....	40
Figure A.4	Deformations from laser gauges on slab 1 test.....	41
Figure A.5	Strain on the rebars in the span under the charge on slab 1.....	42

Figure A.6	Strain on the rebars on mid support on slab 1.	43
Figure A.7	Strain on the rebars in the span opposite the charge on slab 1.	44
Figure A.8	Pressure and impulse density from slab 2 test.	46
Figure A.9	Acceleration on slab 2 test during the first 5 ms.	47
Figure A.10	Displacement calculated from the acceleration of slab 3 test.	47
Figure A.11	Deformations from laser gauges on slab 2 test.	48
Figure A.12	Strain on the rebars in the span under the charge on slab 2.	49
Figure A.13	Strain on the rebars on mid support on slab 2.	50
Figure A.14	Strain on the rebars in the span opposite the charge on slab 2.	51
Figure A.15	Pressure and impulse density from slab 3 test.	53
Figure A.16	Acceleration on slab 3 test during the first 5 ms.	54
Figure A.17	Displacement calculated from the acceleration of slab 3 test.	54
Figure A.18	Deformations from laser gauges on slab 3 test.	55
Figure A.19	Strain on the rebars in the span under the charge on slab 3.	56
Figure A.20	Strain on the rebars on mid support on slab 3.	57
Figure A.21	Strain on the rebars in the span opposite the charge on slab 3.	58
Figure A.22	Pressure and impulse density from slab 4 test.	60
Figure A.23	Acceleration on slab 4 test during the first 5 ms.	61
Figure A.24	Displacement calculated from the acceleration of slab 4 test.	61
Figure A.25	Strain on the rebars in the span under the charge on slab 4.	62
Figure A.26	Strain on the rebars on mid support on slab 4.	63
Figure A.27	Strain on the rebars in the span opposite the charge on slab 4.	64
Figure A.28	Pressure and impulse density from frame 1 test, front gauges.	66
Figure A.29	Pressure and impulse density from frame 1 test, roof and back gauges.	66
Figure A.30	Acceleration on frame 1 test.	67
Figure A.31	Displacement calculated from the acceleration on frame 1 test.	67
Figure A.32	Deformations from laser gauges on frame1 test.	68
Figure A.33	Strain on the rebars on bottom of the front wall on frame 1.	69
Figure A.34	Strain on the rebars on middle of the front wall on frame 1.	70
Figure A.35	Strain on the rebars on top of the front wall on frame 1.	71
Figure A.36	Strain on the rebars on top of the back wall on frame 1.	72
Figure A.37	Strain on the rebars on bottom of the back wall on frame 1.	73
Figure A.38	Pressure and impulse density from frame 2 test, front gauges.	75
Figure A.39	Pressure and impulse density from frame 2 test, roof, back and side gauges.	75
Figure A.40	Acceleration on frame 2 test.	76
Figure A.41	Displacement calculated from the acceleration on frame 2 test.	76
Figure A.42	Deformations from laser gauges on frame 2 test.	77
Figure A.43	Strain on the rebars on bottom of the front wall on frame 2.	78
Figure A.44	Strain on the rebars on middle of the front wall on frame 2.	79
Figure A.45	Strain on the rebars on top of the front wall on frame 2.	80
Figure A.46	Strain on the rebars on top of the back wall on frame 2.	81
Figure A.47	Strain on the rebars on bottom of the back wall on frame 2.	82

LIST OF TABLES

Table 2.1	Summary of the gauges used in the slab tests.	17
Table 2.2	Test programme for the slab tests.	19
Table 2.3	Summary of the gauges used in the frame tests.	25
Table 2.4	Test programme for the frame tests.	27
Table 3.1	Pressure and impulse density in the mid spans.	28
Table 3.2	Deformation in the mid spans for the four tests.	29
Table 3.3	Accelerations in the mid spans.	30
Table 3.4	Maximum pressure at different locations on the frames in kPa.	32
Table 3.5	Maximum impulse density at different locations on the frames in kPa s.	32
Table 3.6	Deformation on the midpoint on the front and back wall.	33
Table 3.7	Accelerations on the midpoint on the front and back wall.	33

ABBREVIATIONS AND ACRONYMS

ABBREVIATION	DESCRIPTION
ICP	Integrated Circuit Piezoelectric
PETN	Pentaerythritol Tetranitrate
RDX	Research Department Formula X (i.e. Cyclotrimetylenetrinitramine))
TNT	Trinitrotoluene
FOI	Swedish Defence Research Agency
TUD	Technische Universität Dresden
GS	GeoSIG Ltd
PCB	PCB Piezotronics, manufacturer of piezoelectric sensors
HBM	Hottinger Baldwin Messtechnik GmbH
ARU	Anglia Ruskin University
LPS	Local positioning system

EXECUTIVE SUMMARY

This report contains a description of the component tests performed within the project RECONASS. The project RECONASS aims to provide a monitoring system for constructed facilities that will provide a near real time, reliable, and continuously updated assessment of the structural condition of the monitored facilities after a natural or manmade disaster. The above assessment will be seamlessly integrated with automated, near real-time and continuously updated assessment of physical damage, loss of functionality, direct economic loss and needs of the monitored facilities and will provide the required input for the prioritization of their repair.

At the end of the RECONASS project, a final test of the system will be performed. In order to test the components for blast impact, and get results which would make it possible to through simulations make estimates and calculations for the final test, these component tests were performed. An additional purpose of the tests was that the sensors developed in RECONASS had the possibility to be tested for blast resistance.

In the component tests, scaled reinforce concrete elements were tested against blast load. In a first test set up four single members, i.e. slabs, were tested with different load, and in a second test set up two multi node structures were tested. In all the tests a large amount of different gauges monitored the blast load and the behaviour of the elements with high time resolution (up to 250 kHz). The design of the tests, such as the amount of explosives and distances, was done in parallel with simulations within RECONASS. These simulations also gave useful guidance in choosing gauges for the test, and provided the sensor development with important information about the durability of the equipment against blast impact.

The simulation and scaled test results showed good agreement, and by using these tests and simulations the design of the final test, the RECONASS pilot test in Älvdalen, will be performed.