DCLG BUILDING REGULATIONS (SANITATION) FRAMEWORK

IMPROVING THE FLOOD RESILIENCE OF BUILDINGS THROUGH IMPROVED MATERIALS, METHODS AND DETAILS

REPORT WP6

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IMPROVING THE FLOOD RESILIENCE OF BUILDINGS THROUGH IMPROVED MATERIALS, METHODS AND DETAILS

REPORT WP6 – COLLATION AND ANALYSIS OF POST-FLOOD OBSERVATIONAL DATA

Report No.: WP 6

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CONTENTS

1.	EXECUTIVE SUMMARY	1
2.	INTRODUCTION	5
2.1 2.2 2.3	Background Objectives for Work Package 6 Layout of this report	5 5 8
3.	OVERVIEW OF COLLATION AND CONSULTATION PROCESS	9
3.1 3.2 3.2.1 3.2.2 3.2.3	Introduction Flood restoration industry Munters/BDMA Belfor FloodPenairNet	9 11 11 12 13
324	ActionDry Emergency Services	13
3.2.5	'PAS 64 - Professional water damage mitigation and initial restoration of domestic buildings'	14
3.2.6 3.3 3.3.1 3.3.2 3.4 3.5 3.6 3.7	'Standards for the repair of buildings following flooding' (CIRIA, 2005) The Insurance Industry Norwich Union Flood Repairs Forum National Flood Forum Boscastle experiences Environment Agency (Midlands Region) Summary	15 15 16 16 16 17 17
4.	CURRENT BUILDING PRACTICES	19
4.1 4.2 4.3 4.4 4.5 4.6	Introduction Barratt Homes (Southern Region) Leadbitter Construction Home Builders Federation National House-Building Council Summary	19 19 19 20 20 21
5.	INFORMATION FROM OTHER PROJECTS/INITIATIVES	23
5.1 5.2 5.3	The FLOWS Project 'Building Futures' (RIBA) Measurement of moisture (University College, London and Glasgow	23 25
531	Caledonian University)	26 26
5.3.2	Thermal probe - research at University College London	20 27
5.3.3	TDR based probe - research at Glasgow Caledonian University	27
5.3.4	Other techniques	27
5.4	Making Space for Water	28

6.	VIEWS ON RESISTANT/RESILIENT MEASURES	31
6.1 6.2 6.3 6.4 6.5	General measures Walls Insulation Floors Fittings	31 32 33 34 35
7.	ANALYSIS OF DRYING DATA FROM OTHER ORGANISATIONS	37
7.1 7.2 7.3 7.4 7.5 7.6	Introduction Measurement of moisture in building materials Rameses data Munters data HR Wallingford laboratory tests Discussion	37 37 39 47 48 49
8.	CONCLUSIONS & RECOMMENDATIONS	53
8.1 8.2 8.2.1 8.2.2	General Recommendations Resilient measures Further research	53 54 54 54
9.	REFERENCES	58

Tables

Main findings from WP6 for resilient measures	3
Table 1. Organisations contacted for production of WP6 report	10
Table 2. Flood resilient measures used in Lowestoft demonstration house	24
Table 3. Resilient measure employed in Cambourne development, Cambridgeshire	25
Table 4. Daily moisture changes averaged for flooded houses and wet walls.	46
Table 5. Moisture change and drying rates for selected flood-damaged structuresand materials.	47
Table 6. Electrical consumption in kW for drying of 2 flood-damaged houses in Carlisle.	47
Table 7. Drying times and rates of walls tested	48
Table 8. Main findings from WP6 for resilient measures	56

Figures

Figure 1.	Role of WP6 in contributing to the aims of the overall project	7
Figure 2	Generic equilibrium moisture content (EMC) curves for different	
	materials (reproduced courtesy of GE Industries)	38

Figure 3	Relationship between %WME and EMC for different materials (reproduced courtesy of GE Industries)	39
Figure 4.	Distribution of samples in the study period (January, February, April, May). Location of sampling points (external walls, internal walls or unknown). Conditions at sample points (dry during the whole study period, dry at the beginning of the study period but wet later on, wet at the beginning of the study period; $n = 375$ sampling points located in 35 houses).	41
Figure 5.	Moisture changes in property 2562.	41
Figure 6.	Moisture changes as WME in property 2526.	42
Figure 7.	Initial and final moisture content at sampling points as wood moisture equivalent (WME) (mean + standard deviation; □, initial conditions; ■, final conditions).	43
Figure 8.	Moisture change (per day) at sampling points (mean + standard deviation) as wood moisture equivalent (WME).	43
Figure 9.	Wall moisture changes (wood moisture equivalent, WME) as a function of the length of the drying period. (n=307, data from dry sampling points were excluded from the graph).	44
Figure 10.	Wall moisture change in wet walls over the study period (mean moisture change + standard deviation; \square , wet walls in general; \square , internal walls; \square , external walls). (n = 285, data from dry sampling points were excluded from the graph).	44
Figure 11.	Moisture change (%/day) in flooded houses (mean moisture change + standard deviation; n = 35; ■, overall house; ■, internal walls; □, external walls).	45
Figure 12.	Frequency histogram of house-averaged drying rates (n = 35).	46
Figure 13.	Frequency histogram of wall drying rates (n = 375)	46
Figure 14.	Wall moisture changes (wood moisture equivalent, WME) as a function of the length of the drying period.	50
Figure 15.	Wall moisture loss as a function of time	51

Plates

Plate 1.	Use of engineered flow paths under new development in Bicester,				
	Oxfordshire (Leadbitter Construction)	20			
Plate 2.	Example of wall monitored by Rameses in Carlisle (April 2005)	40			

Appendices

Appendix 1	Summary notes of meetings/discussions	61
Appendix 2	Summary of reviewed documents	79
Appendix 3	Information provided to Recovery magazine	85
Appendix 4	Examples of data sheets from Rameses and Munters	91

1. EXECUTIVE SUMMARY

This report describes the activities undertaken for Work Package 6 of the research project "Improving the Flood Resilience of Buildings through Improved Materials, Methods and Details" (Ref CI 71/8/5 BD247). The objectives of the WP were:

- To identify and collect observational data on flooded dwellings/buildings (held by other parties) in order to further understand how the flooding process occurs and how it affects a building and its materials during the drying and restoration phase
- To identify current building practices in flood prone areas and their usefulness for flood resilience
- To identify and collect information held by other organizations, networks and research groups that can further develop understanding of flood resilient construction, leading to recommendations
- To complement the results from laboratory tests in WP5 in order to develop comprehensive strategies for flood resilient construction.

The main aim of this exercise has been to collate and analyse experiential data on good and poor materials and constructions, which can be compared against both the WP2 literature review and the extensive results from the WP5 laboratory testing, in order to provide a wider evidence base for the recommendations in the guidance document. This experiential evidence includes personal views based on observation, as well as technical data on the drying of flooded properties. The main activities have comprised:

- Interviews (face to face and telephone) with various groups involved in flood repair/management
- Review of some new documents that have appeared after the WP2 review
- Review of the activities and results of various relevant projects/initiatives
- Analysis of limited drying data from the Carlisle floods.

This data collation exercise has been undertaken as a separate piece of work from the WP2 review, and the groups and documents reviewed are largely different to those reviewed in the previous work. However, the same major conclusions have been reached:

- The majority of effort and interest is currently concerned with the retrofit of resilient measures for existing properties
- There has been limited research on deriving resilient standards for new build
- There have been several publications that provide guidance on resilient measures, since "Preparing for Floods" in 2003, but the material is of a very similar nature, and represents expert opinion and common sense, little is based on hard technical evidence
- Much of the advice relates to the fixtures and fittings, and post-flood repairs (e.g. raising electrics, check valves on service ducts, raising appliances and units above flood level, using plastic/ceramic/steel fittings)

 Advice associated with the main fabric of the house (e.g. use of engineering bricks and render for lower 1 m of wall, use of close cell insulation, microporous coatings/paint) is not backed up by the same level of technical evidence, and has not been used in many case studies.

The WP6 study has unearthed a wide range of views on resilience; some supports the WP2 findings and some of which includes novel ideas, such as rigid insulation with an impermeable exterior. The main findings from WP6 are summarised in the table overleaf. This presents the main consensual views from all the respondents, and relates this back to existing guidance and the WP2 findings, including where this identified that some technical evidence exists. Although there are some favoured materials and constructions, there remains a degree of debate about the effectiveness of many of these measures, which may be due to a large extent on the lack of hard technical evidence. While the strategies for resilient construction put forward from this project will go some way to establishing consensus, further testing and field investigation are recommended in order to develop further the evidence base. One method to do this would be to utilise a small test house facility.

A final part of this study was to analyse some limited drying data that had been obtained from two flood restorers. Because this information dealt only with two material types, and provided insufficient information on the changes in ambient conditions and the amount of forced drying, it was not possible to compare it with the results of the WP5 test. However, it did indicate that there would be merit in producing a more targeted sampling protocol, which the flood restoration industry could use to provide information that would be of more use in assessing the performance of materials and building elements.

Main findings from WP6 for resilient measures

(see Section 8 for more detail)

Good practice								
Construction type	Feature	Mentioned in guidance?	Recommended by	In use?	Tested in WP5?	Comments/recommendations		
General	Move power sockets above flood level	1, 2, 3, 4, 5	Munters	FLOWS	X	In WP2 report		
	Control valves on ducts etc.	1, 2, 3, 4, 5		FLOWS	X	In WP2 report		
	Ground contouring and raising cill levels	2, 4, 5	HBF	FLOWS	X	In WP2 report		
Walls	Sand/cement render	2, 4	Munters	FLOWS	1	In WP2 report (some technical evidence). Need to look at drying properties		
	Lime plaster	1, 3, 4, 6	Belfor	FLOWS	V	In WP2 report. Issue of whether it would be appropriate for new build, due to curing times and specialist application. Need further testing to determine minimum curing time		
	Water-resistant paints and coatings	3, 4			X	Evidence in WP2 report from USACE tests that show some coatings may not be robust. Further testing is recommended		
	Engineering bricks	6	Belfor	FLOWS	\checkmark			
Insulation	Closed cell foam in cavities	1, 3, 5, 6	Belfor		1	In WP2 report (some technical evidence)		
	External self-draining mineral wool batts	3, 4			X	External polystyrene insulation was tested as part of WP5 Stage 4		
Floors	Facilities to pump out	5	Belfor, NFF		Х	In WP2 report		

DCLG BUILDING REGULATIONS (SANITATION) FRAMEWORK

	basements					
	Ceramic tiles, skirting	3, 5, 6		FLOWS	X	In WP2 report (some technical evidence)
	Suspended or solid concrete floor	2, 3, 4, 6	NHBC		√	
Fittings	Steel or plastic units	1, 2, 3, 4, 5		FLOWS	Х	
	Appliances raised on plinths	2, 3, 4		FLOWS	X	
Poor practic	e					
Construction type	Feature	Mentioned in	Recommended by	In use?	Tested in WP5?	Comments/recommendations
		guidance?	organisations			
Walls	Gypsum plasterboard	1, 2, 4, 6	organisations Belfor, Munters	-	V	In WP2 report (some technical evidence). But may be acceptable if lay horizontally and accept that it will have to be replaced
Walls Floors	Gypsum plasterboard Chipboard and laminated floors	guidance? 1, 2, 4, 6 1, 2, 3, 4, 5, 6	organisations Belfor, Munters Belfor, Munters	-	√ √	In WP2 report (some technical evidence). But may be acceptable if lay horizontally and accept that it will have to be replaced Although chipboard was not tested by WP5, the results for OSB, which is another type of particle board, can be taken as fairly representative

1. Repairing your home or business after a flood - how to limit damage and disruption in the future, ABI and NFF

Repairing your nome of business after a nood – now to innit dama
 Design Guidance on Flood Damage to dwellings, Scottish Office
 Repairing flooded buildings, Flood Repairs Forum
 Preparing for Floods, ODPM

5. Flood Resilient Home, Norwich Union

6. Planning Advice Note PAN 69 – Planning and Building Standards Advice on Flooding, Scottish Executive

2. INTRODUCTION

2.1 <u>Background</u>

This project, investigating improvements into methods of mitigating the effects of flooding upon buildings, is divided into a number of Work Packages, as listed below:

- WP1 Establish steering group and project start up
- WP2 Review existing information and experience
- WP3 Consider health and safety implications
- WP4 Define draft procedure
- WP5 Conduct laboratory testing
- WP6 Collation and analysis of post-flood observational data
- WP7 Revise draft procedure
- WP8 Produce regulatory impact assessment
- WP9 Produce guidance document
- WP10 Publish guidance

This report has been prepared exclusively for use in this project and therefore it should not be used in whole or in part for other purposes without the express permission of CIRIA in writing.

2.2 Objectives for Work Package 6

In the project proposal (version 4, February 2005), the title of Work Package 6 was 'Conduct field trials', and it was envisaged that some of the findings from the earlier stages of the laboratory testing could be trialled in the field. However, as the project developed over the year, with a clearer idea of what the testing would deliver and when, the project team considered that effort under WP6 should be directed at collating and assessing 'field' information, rather than undertaking specific trials of new approaches.

The **objectives** for WP6, based on achieving the overall project objectives, were agreed as follows:

- To identify and collect observational data on flooded dwellings/buildings (held by other parties) in order to further understand how the flooding process occurs and how it affects a building and its materials during the drying and restoration phase
- To identify current building practices in flood prone areas and their usefulness for flood resilience

- To identify and collect information held by other organizations, networks and research groups that can further develop understanding of flood resilient construction, leading to recommendations
- To complement the results from laboratory tests in WP5 in order to develop comprehensive strategies for flood resilient construction.

To achieve these objectives, the work package comprised 3 main elements:

- Collation and analysis of post-flood observational data (both qualitative and quantitative) that can be compared directly with the WP5 laboratory testing
- Investigation of current building practices (particularly in flood-prone areas)
- Continuing liaison and collaboration with other on-going research and flood-related initiatives.

This Work Package has provided anecdotal and experiential evidence, which when combined with the rigorous laboratory results, will produce a comprehensive and consensual view of flood resistance and resilience on which to base the new guidelines. Figure 1 shows how the tasks within WP6 fit into the overall project structure and how its outputs will contribute to the final guidance documents.

The principles that have been adopted in WP6 and the project as a whole are as follows:

- The focus will be to identify information appropriate and suitable for use as guidance for flood resilient construction
- Recommendations should be 'evidence based', primarily (but not entirely) using laboratory testing, backed up by any evidence-based experiential data
- The key question to be addressed in all review and consultation work is "What are the implications for the flood resilience and resistance properties of buildings".

Consultation work has been structured according to the draft requirements of the final guidance document.

This report has been written so as to provide a reference document for feeding into the final guidance. It therefore sits alongside the final WP5 report, and includes both summaries of findings and complete meeting notes, so that no information has been discarded along the way.



2.3 Layout of this report

Section 3 provides an overview of the various sources of information that were consulted for this work package. This includes several face-to-face and telephone interviews and discussions with individuals and organisations who are primarily involved in the flood repair process. It was anticipated that they would have first-hand experience of the consequences of flooding, and the views of householders, insurance industry, flood damage repairers and others involved in mitigating the effects of major flooding, which had not already been captured in the information reviewed as part of WP2. This section also includes a review of various key documents that are used during the post-flood restoration, and which were highlighted by the interviewees.

Section 4 presents the views from a limited sample of developers, as to the materials they use in their standard build, and whether they make any adjustments when building in a potential flood-prone area.

Section 5 provides a summary of other related initiatives and projects, and the steps they have taken to address flood resistance and resilience.

Section 6 provides general views on what materials and construction approaches appear to survive flooding best, or indeed which ones were affected the most. This provides a qualitative assessment, as to the most appropriate approaches to use for new build. This summary is derived from the findings from Sections 3 to 5, and is cross-referenced to the main conclusions from WP2, which are also included in the summary tables.

Section 7 presents an analysis of drying data obtained from the flood repair industry, and whether this can be compared to the laboratory results.

Section 8 presents the overall conclusions of this work package, and discusses recommendations for further data collection and analysis that could provide better insights to that possible at the present time.

Appendix 1 contains the summary notes produced from each major interview or discussion.

Appendix 2 provides the summary notes produced on each reviewed document.

Appendix 3 contains the article and associated dummy spreadsheet submitted to the *Recovery* magazine, requesting drying data from the British Damage Management Association (BDMA) membership.

Appendix 4 provides examples of the raw drying data.

3. OVERVIEW OF COLLATION AND CONSULTATION PROCESS

3.1 Introduction

The main aim of the work package, within the normal time and budgetary constraints, was to collate and analyse as much useful information on experiences of flooding, with particular reference to how well the materials and constructions survived and recovered from the flood waters. Clearly, such a consultation exercise can be very open-ended, with new leads and information generated from each interview or discussion. Therefore, the following set of interviews and reviews has to be seen as a limited data set, but one which is considered to be comprehensive enough, and of sufficient depth, to capture the main views and experiences that are of relevance to this project. Another finding from this exercise was that new initiatives are being developed all the time, and it is not possible to produce a static assessment that captures everything. So part of the consultation process was to ensure that others were informed of the outputs and new knowledge that have been created from this project, so that this can feed into and inform other research initiatives.

One of the main conclusions from the literature review carried out as WP2, was that there was very little hard, experimental evidence on how materials and building elements behaved under flood conditions; hence the need for the new laboratory testing. This finding has been confirmed by the current work package, since there appears to be little information collected from which one could draw useful conclusions about different materials or construction forms, other then in a qualitative and experiential way. However, this work package is one of the first attempts to collate such information in one report, and the analysis shown in Section 7 indicates there would be real merit in formulating a structured data collection project, which would address the current lack of information.

Although there are many organisations involved in the flood repair/restoration process, from insurers, loss adjustors to flood repairers, there is no requirement to collect and produce hard evidence to document the restoration/drying process. Therefore the flood repairers will only collect data for their own purposes (to confirm that the property has been adequately restored, such that the next stage of repair can take place). Because this does not conform to any structured data collection framework, it does not easily contribute to the pool of knowledge or evidence base. This issue is discussed further in Section 7.

The full list of organisations and individuals that were consulted is given in Table 1. This also includes reference to key documents that were reviewed, following the interviews. General information from most of the groups is presented below. Information from the building industry is presented in Section 4 and details of the various other initiatives are given in Section 5. Finally, an overall summary of all the views on resistant/resilient construction is presented and discussed in Section 6.

Grouping	Organisation	Individual	tion	Associated document reviewed
			Sec ref.	
Flood Restoration Industry	Munters/BDMA	Mike Waterfield	3.2.1	Standard for repair (CIRIA, 2005)
	Belfor	Laurence Mitchell	3.2.2	PAS 64 (BSI)
		Neal Courtney		
	Rameses	Roger Woodhead	N/A	
	ActionDry Emergency Services	Andy Habbershaw	3.2.4	
FloodRepairNet	Wolverhampton	David Proverbs	3.2.3	
	University	Carly Rose		
	Rameses	Roger Woodhead	3.2.3	
National Flood Forum		Mary Dhonau	3.4	
Insurance Industry	Norwich Union	Jill Boulton	3.3.1	
		Flood Repairs Forum	3.3.2	Repairing Flooded Buildings (2006)
Developers	HBF	Sian Lewis	4.4	
	NHBC	Neil Smith	4.5	
	Leadbitter Construction	Peter King	4.3	
	Barratt Homes	Rob Westwood	4.2	
		Richard Alcock		
FLOWS	Norwich Union	Jill Boulton	5.1	
	Lincolnshire CC	Toby Forbes- Turner	-	
	Royal Haskoning	Fola Ogunyoye		Sustainable Drainage Systems for New Homes – Best

 Table 1. Organisations contacted for production of WP6 report

				Practice Guidance
Architects	RIBA	Ewan Willars	5.2	
Making Space for Water	Defra	Martin Roberts	5.4	
Boscastle	Environment Agency (Flood Defence)	Andrew Houghton	3.5	
	Environment Agency (Development Control)	Frank Newell		
	North Cornwall DC (Tech. Department)	Ken Bouch		
	North Cornwall DC (Building Control)	Jane Duffy		
Association of Building Engineers	Elmhurst Energy Systems	Gavin Dunn	N/A	
Environment Agency	Midlands Region	David Bartram	3.6	

3.2 <u>Flood restoration industry</u>

3.2.1 Munters/BDMA

Mike Waterfield (MW) is very active within the restoration industry, including being on the Executive of the BDMA, and has contributed to previous guidance documents relating to flood repair (e.g. CIRIA, 2005). MW explained (see Appendix 1(1)) that Munters use laptops to record information on site, such as moisture content of walls and floors, and then feed this into a database back in the office. From the very limited data that has been reviewed for this work package, the Munters' database does appear to be the most comprehensive in use by any restoration company. An internet-based system is used, with 'Crystal' reporting to extract information in a variety of forms. An example of an extract from the database is given in Appendix 4 (2). Although there are comprehensive moisture readings taken from each affected room, with details of the type of material/construction, ambient readings may only be taken on the first visit, and there are no records taken of the type and extent of the flood event. Munters do record details of the types of dryers and dehumidifiers that were used, and the time and amount of energy required to return to acceptable moisture levels.

Only more recent flooding incidents are stored in the electronic database, with earlier floods, such as at Lewes (2000) and Northampton (1998), only available in paper form, which are stored at their Huntingdon archive. MW thought that most companies would only have paper

records, and hence expressed concern over how easy and useful it would be to analyse these records. From the examples provided by MW, it appeared that only surface or shallow indepth (10 mm) resistance moisture readings were available, so it would not be possible to determine the actual moisture content within the materials or the relative wetness of the cavity, and external and internal walls.

MW summarised the main steps involved in restoring a flooded property:

- Reconnaissance survey to assess damage
- Decontamination
- Strip out materials if necessary often completed by building contractor
- Sanitise
- Dry out (drying time based on moisture content of walls/ceilings and ambient conditions).

Often the restorer is not consulted on what materials should be kept or ripped out; this is usually dictated by the Loss Adjustor and the policy of the insurance company, with the work carried out by a building contractor. (*Although this view was slightly at odds with that expressed by Belfor*). This could be important in the future, with the use of more resilient materials, to ensure that these are not discarded unnecessarily.

MW noted that many BDMA members would use 'Standards for the repair of buildings following flooding' (CIRIA, 2005) as the basis for their restoration work. This is summarised below in Section 3.2.5.

3.2.2 Belfor

Laurence Mitchell (LM) explained how flood restorers were under pressure to dry the property as quickly as possible, and to try to limit the number of monitoring visits (see Appendix 1(2)). It is assumed that this is primarily on cost grounds. As a result, Belfor does use remote monitoring in some cases, but this relies on the homeowners not moving the equipment following the site visit, which can invalidate the benefit in trying to reduce the drying time.

Different drying methods will be employed, depending on the type and extent of flooding, and the building construction. The most common types of wall and floor constructions encountered are:

Walls

- brick cavity (with or without insulation)
- stud walls with plasterboard (with or without insulation)
- timber framed (with or without insulation)
- solid walls (stone)
- plaster and lath

Floors

- floating floors
- suspended timber floors
- solid concrete and screed.

The WP5 laboratory testing has looked at three of these wall types and one of the floors; the latter being more difficult to test in the laboratory due to size constraints of the test rig.

Drying methods include:

- injection drying using positive and negative air flow into cavities, voids and under floors
- surface evaporation air movement using positive and negative air flow
- direct radiant heat to cause evaporation in solid materials (brick, stone masonry, concrete)
- convectant drying for all materials (without vapour barriers)
- dehumidification
 - a. condensation type for class 1 (porous) and class 2 (semi-porous) materials, and indoor air parcels
 - b. desiccant type for specialist drying below 15 C, for class 3 and 4 (non-porous), cavity drying and indoor air parcels where relative humidity (RH) is required at a drier condition

Belfor will try to find out how and when the property was flooded, and how long the water was in there, as this will help in their diagnosis of where the main flood damage has occurred, and the overall planning and efficiency of the drying regime. A key factor is knowing where the moisture has got to, as the drying process is well understood and the easy part of the process. Cavities create a particular problem, with water able to move freely up the cavity, impeded only by the insulation if present. This can be removed by float-drying, by high-velocity forced drying at the top of the cavity, and bricks removed at the base to allow the saturated air out where the pressure is lower. Contamination, in the form of silt, oil and pesticides, can also be difficult to remove from a cavity. In this case it can be allowed to dry and then vacuumed out, or power-washed to liquefy it and then extracted.

There was further discussion of how to improve the drying process and moisture sampling (see Section 7). Small holes may need to be drilled to check how deep the moisture has penetrated, but they may not be allowed to undertake such invasive surveys. Use of remote, dial-up equipment could reduce the number of visits, although this could increase the time taken before moving the dryers to wetter areas, so may not deliver cost reductions in the long run.

Belfor use PAS 64 as their restoration guide (see 3.2.4 below), which covers the whole process, with BDMA members largely limiting their input to the decontamination and drying phases.

3.2.3 FloodRepairNet

FloodRepairNet (FRN) is a 3-year EPSRC-funded initiative, whose aim is to establish an independent forum in the form of an international network involving the major stakeholders in the repair, reinstatement and resilience of flood-damaged property. Its sponsors include Defra, Environment Agency and BDMA and it is led by the University of Wolverhampton. The inaugural dissemination workshop on the 15th March 2006 was attended, and a follow-up meeting was held at HR Wallingford on the 31st March (see Appendix 1 (3)). This meeting also included Roger Woodhead from Rameses, who was there both as a flood restorer and as a Steering Group member of FRN.

The main objectives of FRN are:

• identification and dissemination of good practice in flood repair / reinstatement and flood claims management

- identification and facilitation of in-depth collaborative research into appropriate flooding and property issues
- critical examination of developments in the use of flood resilient repairs
- developing critical perspectives on the impact of flooding on property owners
- development of an information repository for collation of relevant flood repair publications and literature.

A key part of the meeting was to identify ways in which the resilience project and FRN could work together over the coming year. Agreed collaboration included presentation of a paper at the FRN meeting in September 2006, and for HR Wallingford to host the FRN March 2007 meeting.

The rest of the meeting was concerned with Rameses' views on resilient construction (which are included in Section 6), and other related initiatives. This included the 'DryAir' system which was being tested at Sheffield Hallam University as part of some privately-funded research, and which uses very hot dry air (up to 80 °C), to reduce the drying times from (for example) 3 weeks to 3 days. The National Flood School was mentioned, which provides training courses in drying techniques, consistent with PAS 64 and other accepted proprietary standards. The training also utilises a test house facility, which is unique in Europe.

3.2.4 ActionDry Emergency Services

Brief contact was made with Andy Habbershaw of ActionDry at the InterBuild exhibition in April 2006. They promote the WaterOut system, which is another example of the newer convectant drying systems, which allegedly take days rather than weeks to dry a property. It is similar to the DryAir system discussed with the FloodRepairNet team. Some moisture data was included as part of the information received at the exhibition, which is in a very similar form to that provided by Rameses (see Section 7 and Appendix 4). However, the data only applied to drying of a swimming pool, where there was a problem with dampness. As the internal moisture levels responded to heavy rainfall, it was decided that there was little merit in trying to analyse the data, as it would be impossible to derive meaningful average drying rates.

3.2.5 'PAS 64 - Professional water damage mitigation and initial restoration of domestic buildings'

This publicly available specification (PAS), which forms one of the key guides for the flood repair industry was published in May 2005 by BSI, and was authored by the Chris Netherton of the National Flood School. It acts as a code of practice or guidance, rather than being a British Standard. The aim of the guidance is to return buildings affected by flood damage to their pre-loss condition, assuming this is possible.

The guidance notes that proper Management and Health & Safety procedures need to be in place, to help guide and control the whole restoration process. It sets out procedures to be used for the three main areas that come under the responsibility of the flood damage company, namely:

- Loss mitigation
- Drying
- Cleaning.

The document stresses the setting of targets (drying or cleaning) and adequate monitoring to check on progress and to identify when the goal has been achieved. Issues affecting the restoration process are outlined, such as materials, age of building, extent and duration of flooding. This is compatible with the issues raised in discussion with the above groups. A fuller summary of the guidance can be found in Appendix 2 (1).

3.2.6 'Standards for the repair of buildings following flooding' (CIRIA, 2005)

This guidance document provides a comprehensive assessment of all aspects of flooding impacts on buildings, and how to avoid further damage and losses from future flood events by appropriate repair and mitigation. Obviously, this is aimed at impacts on existing buildings, and what measures can be used to improve their flood resistance and resilience. Although the document was formally published by CIRIA after the WP2 literature review, it had been reviewed by the project team, although this had concentrated on the water ingress routes. The following provides a brief summary of the main part of the document, in terms of its recommendations for resistant and resilient measures, which is not contained in the WP2 report.

The document starts by outlining the key steps involved in the restoration process, providing very similar information to that in PAS 64. The main part of the document is concerned with specifying the range of repairs (materials, techniques etc.) that should be used for each part of the building fabric (e.g. internal and external walls, cavities, fittings). The choice of most appropriate repair technique is based on a comprehensive survey of the damage to the building, using the templates provided, combined with an assessment of the likelihood of future flood events (i.e. a standard flood risk assessment as required for all major planning applications). So if an external wall has been damaged, say by crumbling of the mortar, and if there is a high risk of future flooding, then the guidance recommends re-pointing, but with consideration of also using a polymer-modified render. Although the advice is very comprehensive, there is no numerical data provided. This raises the issue of how much of the advice is evidence-based, rather than being simply expert opinion, and to what extent the information base has been collected in a systematic way.

3.3 <u>The Insurance Industry</u>

3.3.1 Norwich Union

Norwich Union publishes a lot of information on flood resilience on a web site (<u>www.floodresilienthome.com</u>) which was launched during 2005. This was partly related to their involvement in the FLOWS project (see 7.1 below). The site includes recommendations for resilient repairs, and the associated costs and drying times for subsequent flooding events, aimed at demonstrating the benefits from investing in more resilient measures. The dissemination of this information was partly in response to a new survey undertaken in July 2005 by ICM Research, which had revealed a lack of knowledge and understanding of resilience options. Nearly half of the 1086 respondents (homeowners who had experienced flooding) were unaware that alterations could be made to their home to protect it from future flooding, and only 11% thought they had any responsibility for doing so. Over half returned their house back to its original state, often citing cost as the reason for not investing in resilient improvements. One key message from this survey is that it appears to take four flood events

for people to see the benefits of installing flood resilient measures. This lack of technical knowledge on the part of homeowners is not unexpected, since one would expect the insurance and repair industry to be providing such advice. Norwich Union's launch and publicity of the flood resilient demonstration house is therefore an appropriate response to this lack of knowledge.

Notes of a follow-up telephone conversation with Jill Boulton of Norwich Union are given in Appendix 1(5). The main recommendations for resilient construction are included in Section 6 below.

3.3.2 Flood Repairs Forum

This grouping was formed in 2003, involving existing members of the flood repair industry, but with a particular focus on insurers. They have recently published 'Repairing flooded buildings', which duplicates a lot of what is found in PAS 64 and 'Standard for repair', but again it is meant to be aimed specifically at the insurance industry and related bodies. This new document has been reviewed and a summary is given in Appendix 2(2). The book was available at the BRE 'Watertight' workshop (7th March 2006), but was more formally launched by Tony Boobier at the inaugural meeting of FloodRepairNet (15th March 2006). Its aim is to inform best practice for the repair, mitigation and prevention of flood damage. The resilience measures it recommends are based on the Defra guidance 'Preparing for floods' (2002).

3.4 National Flood Forum

A meeting was held with Mary Dhonau (MD) at the NFF's office in Bewdley. She provided an extensive list of potential contacts for advice and information, some of whom had already been contacted. Having suffered from sewer flooding for many years, she has first-hand knowledge of resistant/resilient methods that have worked in her case. The NFF continues to be active and have a high profile within the flood management arena, although it is understood that there are issues over their continuing involvement, mainly due to funding. MD mentioned their conference that was coming up on the 23rd September 2006, and a new factsheet that had just been produced, in association with the ABI, on how to limit future damage and disruption from floods. Finally, the FLOWS project was discussed, and how they had intended to build a flood resilient home, but had largely retrofitted a house in Lowestoft. (*This was borne out by Jill Boulton of NU, who indicated that this had always been the intention, although it is known that a second development at Cambourne has included some resilient measures, even though the main emphasis seems to be on SUDS.A full description of the two FLOWS demonstration houses can be found in Section 6.1).*

3.5 Boscastle experiences

One of the main aspects of the Boscastle flood was that because this was a flash flood in a steep catchment, damage from large debris was more of an issue than the ingress of water. Most of the affected houses were of the traditional stone/brickwork construction (400-600mm walls), with "lath plaster", which appears to be lime plaster, possibly on batters. Both this and the stonework survived very well. Forced drying was used in the majority of cases, taking 1-2 months to dry out, although some took up to 8 months. The traditional clay mortar is very porous and this let in a lot of water, producing long drying times for the brickwork. Many properties had flagstone floors, which were very easy to clean.

Because of the traditional building and appearance considerations, the introduction of resilient measures has been limited. This has followed Environment Agency guidelines, with raising of ground/floor elevations where possible, use of non-return valves for services, plasterboard laid horizontally, and waterproof admixtures for external renders for lower 1 m of the wall. Some reconstructed properties are still lying in the flow path, and therefore means to withstand debris impacts have been considered. Some conflicts were identified between Environment Agency advice on raising floor levels, with need for disabled access as set out in Part M of the Building Regulations.

3.6 Environment Agency (Midlands Region)

An example was provided of a new store in Leicester, where the floor levels could not be raised above the 1 in 100 year + 20% flood level due to access requirements. Above this it was agreed that resilient designs would be used, conforming to national Environment Agency policy, in preference to dry proofing, because of the acceptance that water will always get into buildings.

A solid blockwork frame was used, with prefabricated concrete panel walls slotted in between. Render was used on the walls, rather than plasterboard, and a waterproof additive was also used on the external wall. The floor was a solid concrete slab, with damp proof membrane, with ceramic tiles vibrated into a wet screed. The aim was to provide a barrier to uprising water, and facilitate easy cleaning. Electrics were excluded from this waterproof zone. Stock was also kept above the wet-proof zone.

3.7 <u>Summary</u>

The above section has tried to present a comprehensive overview of the views and opinions of those involved in the restoration of flooded buildings. It may well be one of the first attempts to collate such information into one place. Views were expressed on what materials and construction forms appeared to survive well from flooding, and these are presented in section 5 below. The main conclusions that one can draw from this experiential evidence are as follows:

- The flood repair industry is well–established and contains many players, covering both distinct and overlapping roles
- The vast majority of knowledge, effort and experience relates to restoration of buildings there is very little that relates to the inclusion of resilient measures in new properties or for which there is hard evidence to back up such decisions
- Several new publications have come out since the start of 2005, but they largely deal with the same material, are not backed up by any hard evidence, but represent common-sense, expert views. This may well apply to the best practice guidance that is being used
- The take-up of resilient repairs still seems to be somewhat haphazard, with the insurance industry providing better advice, but with the onus put on the homeowner to pay for the betterment. However, the actual recommendation of such improvements, in the aftermath of a flood, may reside, at least in part, with the Loss Adjustor; none of whom have been interviewed for this report.

4. CURRENT BUILDING PRACTICES

4.1 Introduction

A limited amount of liaison was undertaken with developers, National House-Building Council and the Home Builders Federation (HBF), to ascertain:

- whether practices were varied when building in flood-prone areas
- their response to new recommendations on more resilient build.

4.2 Barratt Homes (Southern Region)

Barratt use standard brick and block designs for their residential developments, which conform to Robust Details. These use higher insulation standards for affordable homes, but make no other major changes to the design. Although they currently don't build timber frame houses, they are starting to look at this. They make no concessions for building in flood-prone areas, and indeed the view was expressed that one should not be building in such areas. Because margins are tight, the issue of using more expensive materials to increase resilience did not appear attractive, and overall they did not see any merit in trying to promote a house that was more resilient to floods.

There is little offsite construction in Southern Region, although the Group as a whole is moving more in this direction. Discussed the upgrading for floors by using 75mm phenolic foam with screed. For walls, they use partial fill lath, with Thermoeconomics *Ultratherm* board. This type of insulation (Alreflex) is like bubble wrap with silver foil on the sides, which would appear to have minimal take-up of water, based on the testing of foam insulation in WP5, but its drying properties, as part of the wall, would need to be assessed.

4.3 Leadbitter Construction

The Social Housing Manager for Leadbitter indicated that their design philosophy is not to use flood protection measures, or indeed resilient measures for their developments. Rather they prefer to work with the natural flow routes of watercourses and overland flow. So rather than trying to protect the house from water ingress, they use trenches and other flow routes underneath the houses to allow the water to move away as quickly from the building. Each case will be looked at on a site-specific basis, and will utilise a flood risk assessment to inform the best 'hydraulic' solution. If they install flow routes under the building, they will sometimes suspend the drainage to the underside of the slab. They therefore do not consider resilience in their designs, as we are defining it in this project, although they will use brick and blocks of a certain quality to withstand flood water. Plate 1 shows a new development in Bicester, Oxfordshire, where they are allowing water to flow under the house from the adjacent ditch.



Plate 1. Use of engineered flow paths under new development in Bicester, Oxfordshire (Leadbitter Construction)

4.4 <u>Home Builders Federation</u>

Further responses are awaited from HBF members to the e-mail sent out by HQ, but the views expressed to date indicate that whilst flooding is considered when planning a new development, the aim will be to 'remove' the flooding risk, so that resilience is not needed. So using the results of a flood risk assessment, the developers will work with the Environment Agency to engineer the design, by ground contouring, raising door threshold levels, planning of flow routes and provision of flood storage, such that a standard building construction can be used. The main impetus behind this, other than the cost savings from using a standard design, is that developers do not want to advertise that a house has been built with resilient features, even if this is to cover a very unlikely residual risk.

4.5 National House-Building Council

Several of the above themes were restated by Neil Smith (NS) of NHBC, particularly that building shouldn't be taking place where there is too high a flood risk, and hence the need for resilience should be limited to a small number of homes. A key aspect for the project to consider was whether definitive guidance could be given, such as the benefits of framed

versus masonry construction. Measures that allow a house to be dried quickly and effectively were considered to be the most important. For example, a timber frame wall allows the wet lining to be removed easily, the property to be dried, and then the lining replaced. NS noted that BRE Certification had recently brought out a new Standard (LPS2020) in April 2006 concerned with the certification of innovative systems, elements and components for residential buildings. LPS2020 makes specific reference to the effect flooding would have on the homes. Although it will not be possible to include a review of this document in this report, if appropriate, it will be assessed as part of the production of the WP9 guidance.

4.6 <u>Summary</u>

For medium to large developers it is clear that they will favour standard designs that can be used across the whole of the UK, with no need for consideration of site specific issues, since this will bring cost benefits. On the other hand, more local and specialised developers, who may be building a certain type of dwelling in a specific location, they can afford to consider site-specific design issues. However, from the limited evidence presented above, all groups recognised the importance of assessing the flood risk, but neither group wished to use resilient measures. Instead, the preference was to take action higher up in the response hierarchy, by engineering out the flood risk. PPS 25 will support such a view, in trying to avoid building in high flood risk areas, and in trying to minimise the residual risk. However, a key challenge in producing the WP9 guidance document, in terns of the above responses, will be the extent to which it will influence common designs and be taken up by developers.

5. INFORMATION FROM OTHER PROJECTS/INITIATIVES

5.1 <u>The FLOWS Project</u>

This important project has just finished at the end of June 2006, with a 3-day conference in Cambridge. The overall project was funded by the European Regional Development Fund/Norwegian ERDF under the Interreg IIIB programme, and ran for 45 months from November 2002. Covering the North Sea region, the countries involved comprised the Netherlands, Norway, Sweden, Germany and the UK. The overall theme of the project was 'living with flood risk in a changing climate', and aimed to develop guidance and best practice on how to respond to the flood risk challenge. This was achieved by a series of contrasting case studies from across the study areas, with the particular aim of sharing practice and knowledge. The outputs from the project have been summarised under 5 main themes:

- 1 & 2 Perception and raising awareness of flood risk
- 3 Acceptable levels of flood risk
- 4 Responding to flood risk
- 5 Working together to tackle flood risk.

Theme 4 was the most relevant to this project where it was considered that there are three basic choices: resistance, resilience or retreat. This topic was covered by several of the presentations and workshops at the final conference. Resistance was seen as potentially less sustainable and more costly in the long run, and that greater attention should be given to resilience and retreat, and thereby living with and adapting to the flood risk. Although this view is largely borne out by the outputs from WP2 and this work package, small-scale resistance in the form of ground contouring and raising of cill levels would appear to offer low-cost and robust options.

This approach has been demonstrated by several case studies, completed under two of the three work packages. Under FLOWS work package 2, Public Perception of Flood Risk, there has been a retrofit of a heritage site in the UK, a residential retrofit of the ground floor of a property in Lowestoft, an office retrofit in Upware, Cambridgeshire and the retrofitting of a flood barrier at a lagoon outlet in Sweden. All of these studies aimed to raise awareness of the different types of flood risk, and to show that cost-effective methods are available. Work package 3 was concerned with Spatial Planning and Water Management, and attempted to produce best practice for improving the integration of flood risk information in the spatial planning process. The main conclusion of interest was that measures are available to increase the flood resilience of existing and new buildings, thereby reducing the likelihood and consequences of flooding. The main case studies involved a new residential project, which included sustainable drainage systems and some resilient methods, and a demonstration project in Great Yarmouth, which looked at various costs and options for a new office complex, including raising ground levels and hardening the building to reduce damage from flooding.

The residential retrofit project in Lowestoft has already been mentioned, and this is used as one example for the Flood Resilient Home web site of Norwich Union. A site-specific flood risk

assessment for the property was used to identify the type of flooding that could occur, and to develop appropriate mitigation options. In addition to fitting floodguards on the doors, in response to two flood events, the following resilient measures have been used (Table 2).

Items removed	New resilient features		
Vinyl flooring from kitchen	Ceramic tiles walls, floor and skirting		
Thermoplastic tiles and carpet from rest of downstairs	Walls replastered up to 1 metre above floor level with Limelite Renovating Plaster		
Skirting, wall tiles and plaster	New internal doors, linings and frames, to make them easier to remove		
	Major appliances raised on plinths Raised electrical points New steel kitchen units raised off ground		
	New waste system and double-check valves		

The floodguards provide sufficient time and protection to allow possessions to be moved upstairs, and the resilient features will allow the property to be more easily cleaned and dried, so that re-occupation can take place within hopefully 48 hours.

The second FLOWS case study of relevance to our project is the Lamb Drove development in Cambourne, Cambridgeshire. This is a showcase project to demonstrate a sustainable water management scheme, to reduce flooding impacts and to bring environmental, social and ecological benefits to the community. Although principally a SUDS scheme, some resistant and resilient measures have been used in two properties, to illustrate possible techniques and promote their take-up by the flooding community. The Lamb Drove site is not at flood risk from an existing watercourse, so the case study is purely for demonstration purposes, to show what can easily be used in any new development. Alongside the show house, a new best practice document has been produced, covering the lessons learnt from the application of the SUDS and resilient measures. Although the Cambourne house is one of the few examples that have been found where true resilience has been built into the construction, the fact that it may experience no major flooding means that there will be no opportunity to determine the performance of these features in a real flood situation.

The features included at Lamb Drove are given in Table 3.

Construction type	Measures		
Elevation	Finished floor levels were raised at least 300mm above the surrounding ground levels, which were contoured to slope away from the properties		
Dry proofing	Raising level of services and other flood routes, such as doorways and vents		
	Use of water-resistant buildings materials (e.g. engineering bricks, render and mortar) for first 600-900 mm of external walls		
	Use of non-return valves/drain stops		
	Use of barriers or covers for external openings, such as vents or doors		
	Adequate drainage design for DPC		
	Provision of sumps and mobile pumps for below ground drainage		
Wet proofing	Raising of boilers and other water-sensitive equipment above ground level		
	Use of resilient materials and finishes such as PVC skirting and treated wood		
	Raising of internal sockets above 1m and use of water-resistant cabling		
	Removable partition wall panels for first 900mm of wall height		
	Use of dado rail as visible indicator of flood resilient level		

Table 3. Resilient measure emplo	oyed in Cambourne	development,	Cambridgeshire
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The above options from the two demonstration houses have been included as part of the overall assessment of resilience in the next section.

5.2 <u>'Building Futures' (RIBA)</u>

Building Futures was established in April 2002, as a joint initiative between CABE and RIBA, as a means to discuss and debate the needs from the built environment over the next 20 years and beyond. The main aims and objectives have been:

- To promote public and political debate on the future of the built environment
- To influence and involve a range of stakeholders
- To anticipate and analyse developments affecting urban design
- To use a mix of media for the initiative (such as publications, workshops, exhibitions)
- To collaborate with key individuals and groups.

The initiative is now run solely by RIBA, since May 2005, and has to date produced various documents, covering themes such as 'Urban life in an age of complexity', 'Housing Futures 2024', 'Learning Environments of the Future: Libraries', '21st Century Schools' and 'Professional Futures'. These have largely comprised a series of papers written by active researchers/practitioners in the relevant field. Of direct relevance is the flooding project, 'A Flooded Future'. This was initiated at a meeting in October 2005, and aims to improve the response of architects and other agencies to the challenge posed by the increased risk of flooding, caused by both climate change and development pressures.

The project is intended to be composed of two parts; the first will comprise a stimulating discussion paper outlining the threats posed by flooding and the response to that risk in the light of construction and design thinking, from perspectives provided by a range of professionals. This first stage is underway, and it is proposed to launch this document at an inaugural Building Futures 'Futures Fair', a joint venture with the DTI, which will showcase the UK futures research community. This is currently planned for October/November 2006. The discussion document will have 5-6 high profile contributors, such as the architect David Price, who will address emerging issues in the Thames Gateway, East Coast of England areas and experiences from living with floods in Holland.

The second main output will be a more practical document that highlights examples of architectural solutions to flood risk. To date this has only been scoped out, and work will commence following the research event. It is planned that this practical document will look at materials and methods for flood resilient design, and will be aimed at architects. In discussions with Ewan Willars (Head of Policy at RIBA), it was agreed that there were opportunities for collaboration between our two projects, or that possibly a new project could be formulated, as RIBA are looking for new funding streams to progress this work. At this stage it doesn't appear that there will be any clear recommendations coming out of the RIBA project to feed into the WP9 guidance; rather our project should work with and help to guide the developing views amongst architects on resilient designs.

5.3 <u>Measurement of moisture (University College, London and Glasgow Caledonian</u> <u>University)</u>

5.3.1 Overview

The proposals for WP6 included liaison with other organisations involved in research on moisture in buildings. The accurate measurement of moisture in building materials is a complex subject which is the subject of ongoing research. Part of the impetus for this new research is the acceptance that moisture is commonly measured using surface resistance techniques. As such, this can be affected by the chemical composition of the materials, such
as salts forming near the surface following wetting. Also, the surface readings may not reflect the extent and distribution of moisture actually in the materials. Further information on moisture measurement can be found in the WP5 report.

Achieving accurate measurements on composites, such as walls, is further compounded by the presence of different materials and their varying behaviours in relation to the presence of moisture. Although the method used for the WP5 laboratory testing is consistent with that generally employed by the flood restoration industry, it was also apparent that several promising methods are currently in a research and development phase. These were deemed unsuitable for the present study as they could not be easily used in the test rig and would also not guarantee the level of confidence/accuracy that they in theory should provide once all the research and development work is finished. Information gathered from several sources on these new methods and other existing techniques is summarised below (which is reproduced from the WP5 final report), given that a large part of the WP6 activities has been concerned with the measurement of moisture.

5.3.2 Thermal probe - research at University College London

The system being developed at UCL is a thermal probe which appears at this stage to require calibration for every material; the status of the development work is not sufficiently advanced to allow meaningful results if the probe were to be used in the current project.

5.3.3 TDR based probe - research at Glasgow Caledonian University

Researchers from Glasgow Caledonian University have been granted over £225,000 to investigate the effects of moisture on the fabric of buildings. The three-year study, funded by the Engineering and Physical Sciences Research Council, will look at the effects of weather damage on historic buildings in Scotland and other parts of the UK The system being developed at Glasgow Caledonian University is based on time-domain reflectometry (TDR), using a radio signal and a computer to detect and collect data on moisture. The probe being developed is an improvement on a German probe, with 100mm long prongs which need to be inserted into the wall/floor through two parallel 2mm diameter holes. The research work is looking at reducing the length of the prongs from 100mm to 50mm (but some loss of accuracy is expected, which will need to be evaluated); there are also concerns about the feasibility of drilling the parallel holes on site, particularly in concrete which can have very hard aggregate. The probe provides an average moisture value through the 100mm length of the prongs and readings can be affected by the presence of metallic or magnetic elements in the materials. Due to its complexity, this system is not expected to be used by the average surveyor but by specialist ones only. Trials are planned on some Historic Scotland sites in 2007. The system is quite sophisticated and, as it was still in a development stage, the advice received was that it was inappropriate for use in the Resilience project.

5.3.4 Other techniques

The WP5 final report contains further discussions of alternative measurement techniques and the practical difficulties of obtaining meaningful moisture values. This includes the timber dowel technique and core drilling. Neither of these was considered suitable to be used within the later stages of the WP5 testing. The overall conclusion from discussions with Caledonian University is that collecting data on internal moisture currently is difficult, ultimately unreliable

and is still in the research stage. Until the methods used by the flood restoration industry are better understood, and the extent to which they do not entirely rely on surface resistance measurements, the approach taken in WP5 has been the correct one, in terms of producing compatible results. This issue is discussed further in section 7.

5.4 Making Space for Water

The following text has been taken directly from the MSfW update (Defra, 2006), which was prepared for the recent Defra conference in early July. MSfW contains many projects, of which RF1 and RF2 are concerned with resilience. These are being managed by Martin Roberts (Defra) and Matt Crossman (ABI). The first aspect (RF1) will involve carrying out a feasibility study on resilience grants, pilots and advice schemes, undertaken by Defra. The second area of work (RF2) will be to develop alternative methods of encouraging uptake of resilience, undertaken by ABI.

RF1: Resilience Pilots

The overall aim of this project is to identify new and improved ways in which the public can be encouraged to incorporate appropriate flood resilience or resistance measures in their homes and businesses. In order to achieve this, a feasibility study into the possibility of a grants pilot scheme will be carried out. Any pilot scheme would concentrate on areas where communities are at risk from flooding but are unlikely to receive any community flood defence schemes in the foreseeable future.

RF2: Encouraging Uptake of Resilience Measures

The second aspect of this project will look beyond the pilot scheme at wider measures and actions to promote the uptake of resilience and resistance measures. It is intended to identify key actions required to overcome these barriers and develop an action plan for key stakeholders to improve the uptake of potential measures.

This project will also be responsible for improving current information and advice available and undertaking a survey into how the public could be encouraged to take up resilience measures. As part of this the aim will be to establish a single contact point for resilience information. Additionally, work will be carried out with a number of key stakeholders to identify ways in which they can directly encourage uptake.

Progress so far:

- **April 2006:** Resilience factsheet published, prepared jointly by Association of British Insurers and National Flood Forum.
- **July 2006**: Literature review underway, which aims to identify appropriate funding sources for the pilot scheme and make recommendations as to whether there is scope for further funding post-pilot.

Forthcoming Milestones:

- Autumn 2006: Stakeholder Workshop to be held to help steer the projects forward.
- December 2006: Feasibility of pilot scheme complete

- February 2007: Roll out pilot scheme, including identifying potential pilot areas
- Winter 2007: Provide an assessment of Pilot.

Although the above projects form an important part of the country's overall future response to flood risk, it is not clear to what extent they will add to the knowledge of the resilient properties of buildings and materials.

6. VIEWS ON RESISTANT/RESILIENT MEASURES

Based on the interviews and discussions described above, plus the review of new documents that have come out since the start of the project, the following sections provide a concise summary of the views expressed on "good" and "poor" practice in resistant and resilient approaches. These findings complement, and sit alongside, recommendations from existing guidance. Whilst the range of views identified from WP6 are not very different to what has already been identified and collated, for example in 'Preparing for Floods', 'Standards for repair', or in the WP2 literature review, such a finding is still of value. This section refers to both resistant and resilient measures, since some confusion exists within the flood repair industry as to where certain measures should sit. Rather than exclude any views from this information collation exercise, the following tables include all of the measures raised, even if they are clearly flood resistant options. The tables simply present a range of examples of good and poor practice, and are not structured to present both the positive and negative aspects of particular methods (i.e. they are not meant to be read across the page).

The following tables present a simple collation of the views expressed during the interviews, and do not attempt to cross-reference or check their consistency. In particular, materials may operate in different ways, depending on the actual construction used. For example, whilst there is general agreement that mineral fibre does create problems in cavities, it may perform quite well if applied as external wall insulation, potentially even performing better than closed cell foam. Therefore the following tables should be viewed as a limited sample of views from experts in the flood management field. It also has to be recognised that in the main, these are personal opinions, which may not be backed up by hard evidence. Where a particular measure was recommended in the WP2 report, this is shown in the table. Where this is backed up by hard data, as in the case of the Oak Ridge testing in the States, this is shown in red.

"Good J	practice"	"Poor practice"			
Feature	Organisation	Feature	Organisation		
Move power sockets above flood level	Munters, NFF, FLOWS, FRF, Norwich Union, WP2				
Move electrics at least 1 metre above floor level	FLOWS				
Use 'open-drying' materials (e.g. wood, plaster, bricks) – assume this means materials that allow water to move to the surface and	Belfor				

6.1 <u>General measures</u>

DCLG BUILDING REGULATIONS (SANITATION) FRAMEWORK

evaporate		
Telescopic air brick covers	Norwich Union, FRF, WP2	
Landscape ground away from house, raise floor levels	FLOWS, Norwich Union, HBF, WP2	
Non-return valves on service ducts	FLOWS, FRF, Norwich Union, WP2	

The above options are largely endorsed by all the organisations consulted, and are ones that could be included as part of the overall design of the development, without incurring excessive cost. A flood risk assessment will be needed to confirm the depth and other characteristics of the typical flood event, but raising of services and/or use of one-way valves, plus ground contouring, will reduce the amount of water that gets into a house, as long as the flood event is not of long duration. Obviously where the flood depth is several metres, raising of services is unlikely to be effective.

6.2 <u>Walls</u>

"Good practice"		"Poor practice"			
Feature	Organisation	Feature	Organisation		
Avoid cavities if possible	Munters	Plaster (gypsum) – if moisture is trapped behind it can be difficult to dry the wall material	Munters		
Sand/cement render (external or internal) – good at letting water out	Munters, NFF, FLOWS, WP2	Render – can be a problem if get moisture behind (so needs to be able to breathe)	Belfor, FRF		
Lime "renovating" plaster – good control of dampness through plastered walls in old buildings	Belfor, NFF, FLOWS, FRF, WP2	Gypsum plasterboard, especially if used with fibreglass insulation (often has to be removed)	Belfor, WP2		
Engineering bricks (but take long time to dry if get wet from above, and also	Belfor, FLOWS	Steel-frame – replacing damaged wall insulation, which is generally external	NHBC		

DCLG BUILDING REGULATIONS (SANITATION) FRAMEWORK

depends on type used)		to the frame, has been raised as an issue	
Tanking of basements and partly up the walls (some concern from NHBC about getting this right and therefore being effective)	NFF, Rameses		
Impervious membrane down the cavity	NFF		
Reinforced cement/gypsum board	Rameses, WP2		
Water-resistant coatings (external and internal)	FRF	Water-resistant coatings (USACE work showed that certain coatings often failed and few were robust)	WP2
Microporous paints	FRF		

Some consensus on wall constructions emerge from the above, such as the use of sand/cement renders to reduce water penetration, although there is a recognised issue about whether they would impede drying of the internal building fabric. Gypsum plasterboard is seen as not flood resilient, but if accepted that it will be removed and replaced, it still has a role to play, particularly if it placed horizontally. Use of lime plaster is mentioned by several groups, but this is at odds with the WP5 results, for good reasons, and given the extended curing times and higher skill in using, it is difficult to see that it would find much favour among the major developers. There are conflicting views on some water-resistant coatings, and further testing would be needed to confirm the USACE results. If there were only small depths of flooding, then the use of engineering bricks backed up by render would appear to provide reduced water penetration, especially if control valves were also used on service entries. The notion of avoiding cavities is interesting, since this is an important feature in preventing rain penetration.

6.3 Insulation

"Good practice"		"Poor practice"		
Feature	Organisation	Feature	Organisation	

Avoid insulation in cavities if possible.	Munters, WP2	Corrosion resistant wall ties and fixings	FRF
Closed cell foam insulation – even better if sealed on all sides	Belfor, FRF, WP2, Norwich Union	Mineral insulation	Norwich Union
Self-draining mineral wool batts	FRF		

All the evidence would seem to indicate that some form of closed cell foam was the preferred cavity insulation, although other forms may be equally suitable if used on the external wall. NHBC view was that it was not possible to avoid insulation in cavities, using current designs. Also, the issue of corrosive wall ties should no longer be an issue as Part A of the Building Regulations specifies stainless steel.

6.4 <u>Floors</u>

"Good p	"Good practice"		practice"
Feature	Organisation	Feature	Organisation
Facilities to pump out basements	Belfor, NFF, Norwich Union, WP2	Laminated floors	Munters, Belfor
Solid plastic laminates	Belfor	Suspended chipboard	FRF
Solid wood floors, if pressure treated and with good void underneath	Belfor	Insulation under concrete screed	WP2
Ceramic tiles, skirting	FLOWS, FRF, Norwich Union, WP2		
Suspended or solid concrete, 'beam & block'	FRF, NHBC		
Denser concrete screed on solid floor slabs	Norwich Union		

Suspended or solid concrete floors are the preferred option, with a suspended floor allowing for drying underneath if necessary. If flooding is likely, especially if this is from groundwater,

the facilities to pump out basements are seen as crucial. There is a lot of evidence that materials that can be easily dried and cleaned should be encouraged; this would include ceramic and plastic tiles, skirtings etc. Standard laminated and chipboard floors are to be avoided, as they will nearly always need replacing. Floor insulation needs careful consideration, as this may be difficult to dry if covered by screed.

6.5 <u>Fittings</u>

"Good practice"		"Poor practice"			
Feature	Organisation	Feature	Organisation		
Have furniture etc. that can easily be moved	Munters	Chipboard units and panels			
uPVC doors with good seals	Belfor				
Steel or plastic kitchen units	FLOWS, FRF, Norwich Union				
Main appliances raised on plinths	FLOWS, FRF				

The views on fittings highlight the issue of new build vs. resilient measure for existing homes. Raising appliances on plinths and providing 'non-standard' kitchen units would advertise the flood risk, and therefore would be seen as unattractive for developers. However, they would be entirely appropriate for existing homes, where more frequent flooding had been experienced. Some unobtrusive raising of appliances may be feasible, although the location of service penetrations should also be considered in terms of the likely flood depth. Measures recommended for service penetrations for homes at risk from gas contamination may also be applicable to flood protection.

7. ANALYSIS OF DRYING DATA FROM OTHER ORGANISATIONS

7.1 Introduction

One of the main conclusions from the WP2 literature review was that very little primary data exist that describes the resilient properties of normal building materials, or constructions. Since it is difficult to collect real field data on water penetration into a house, because of the practicality of knowing when a flood would occur and of having the right equipment in the right locations, research is reliant on collecting information on the aftermath of a flood. In practice, this means collecting information on the condition of the flooded property, and the change in moisture content as the property is dried and restored. Such data collection is the normal responsibility of the flood repair industry.

As a result of the initial contact with Mike Waterfield of Munters, the request for data from flooded houses was raised at an Executive meeting of the BDMA. Subsequent to this, HR Wallingford was also contacted by the Editor of the BDMA *Recovery* magazine, to include a short article in the Spring 2006 edition, setting out the need for the information, and what was required. A dummy Excel spreadsheet was produced in the hope that this would facilitate the provision of data, although it was accepted that BDMA members may not have the data, or that it was difficult to provide it in the format requested (see the comments above in Section 3.2). The article and spreadsheet are included in Appendix 3. To date, there has been no response to this data request.

Notwithstanding the positive interviews with Munters and Belfor, several follow-up e-mails and telephone calls have failed to deliver any additional data. Therefore the analysis below is based on the two examples provided by Munters, and the more extensive data set from Carlisle provided by Roger Woodhead from Rameses. This has been compared with the WP5 laboratory results and other general published data.

7.2 Measurement of moisture in building materials

Before embarking on an analysis of the limited drying data that have been received, it is worth summarising some general principles behind the collection of these data. Generally, three types of moisture meter are employed by the flood repair industry:

- A Protimeter (or similar) that measures %WME (wood moisture equivalent) of surface materials, using either two short probes or a sensor plate on the back. (HR are using a pinless moisture meter (Electrophysics CT100), which uses a sensor plate)
- Long relative humidity probes (such as manufactured by Vaisala) for use in cavities
- A Calcium Carbide device ("speedy moisture meter") which measures the amount of gas given off by a weighed sample (normally concrete or brick) in proportion to the amount of moisture present. (Although this is a common form of moisture measurement, as evidenced by references to its use in Appendix 1 and 2, issues over the extraction of samples discussed in Section 5.3 are also relevant. So a poor drilling technique, that may be fast or aggressive, may heat the substrate and cause drying of the drill dust).

In the past, GE Industries, who produce the Protimeter, used to provide generic tables relating WME to actual moisture values. However, because the information was being misused or misinterpreted, the normal practice within the industry now is to only quote %WME, which provides a consistent approach as long as it is clear that this only applies to surface readings. The following figures (2 and 3) show the generic moisture curves for different materials. The values are Equilibrium Moisture Content (EMC), which means that they have stabilised with respect to the relative humidity of their environment. 16% WME acts as a 'magic number'. separating dry materials from those that are at risk, since it has been found that biological attack, in the form of dry rot, starts to take place above this important threshold. The consequence of this relationship is that if a set of wall elements was found to have the same % WME of 20% (at risk), the wood would be at 20% EMC, plaster at 1-3% EMC, bricks at 2-5%EMC, and the cement mortar at 5-7%EMC. This is obviously a simplification of what is likely to happen in reality, because it assumes equal 'wetting' of all the materials and doesn't allow for interactions between them or variation in the material compositions. But it does illustrate how surface moisture readings can be difficult to interpret from actual building elements.



Figure 2 Generic equilibrium moisture content (EMC) curves for different materials (reproduced courtesy of GE Industries)

condition as the critical %mc thresholds for wood are known.

Equilibrium moisture content - %mc guidance values									
						generic			
Environment					generic	sand &			
or material		generic	generic	generic	cement	cement	generic	Protimeter	
condition	%rh	wood	plaster	brick	mortar	screed	concrete	WME	
	25	6						6	
	30	7						7	
	35	8						8	
	40	9						9	
	45	10						10	
safe	50	11						11	
air dry	55	12				4.7	3.9	12	
	60	13				5.1	4.2	13	
	65	14	0.1	1.0	1.5	5.5	4.5	14	
	70	15	0.2	1.3	2.0	5.9	4.8	15	
at risk	75	17	0.4	1.6	3.0	6.4	5.2	17	
	80	18	0.6	2.4	4.0	6.8	5.4	18	
	85	20	1.0	3.0	5.0	7.3	5.7	20	
	90	23	1.5	4.0	6.0	8.0	6.0	23	
damp	95	26	2.2	5.5	7.7	9.0	7.0	26	
	100							27	
								28	
								relative	
								relative	
				DROTH	\rightarrow			relative	
				PRUTI	HEIER			100	
Protimeter W	ME - wo	od moisture	e equivelant	. This is the	theoretical 9	%mc value th	at would be a	ittained by	
a piece of woo	od in co	ntact with a	nd in moistu	ire equilibriu	m with the r	naterial unde	r test. Protim	eter WME	
measurements can be used directly to establish if non-conductive materials are in a dry, at risk or damp									

Figure 3 Relationship between %WME and EMC for different materials (reproduced courtesy of GE Industries)

7.3 <u>Rameses data</u>

Moisture data were provided for 375 locations in 35 households from Carlisle, with surface readings taken in various external and internal walls. An example is shown in Appendix 4 (note that values are quoted as REL ('relative') where 20% WME is 200 REL; i.e. they are simply multiplied by a factor of 10, which seems to be an approach used within the industry). There was no record of the type of material that was tested (e.g. wood, brick), nor of the type and number of drying units used and the subsequent energy use. However, it has been confirmed subsequently that all walls were made of brick, with all saturated plaster being removed prior to commencement of the drying (see Plate 2). Drying targets were set according to unaffected areas, although because several of the properties had problems with existing DPCs, the 'normal' moisture was higher than the 16-20% WME expected. Because Rameses tanked the walls, they were able to commence reinstatement before the normal drying target was achieved (i.e. when most readings were still in the mid to high 20s). The amount of drying equipment needed in each property was determined by the Moisture Wizard which can be found the National Flood School web software. on site (www.nationalfloodschool.co.uk/isd mw pas64.htm). This assesses the room dimensions, relative humidity and air temperature, and recommends the amount of air movers and dehumidifiers required.



Plate 2. Example of wall monitored by Rameses in Carlisle (April 2005)

Moisture readings were taken over the period January to May 2005, and Figure 4 summarises the distribution of the readings, noting the month in which readings started. So readings in some houses only started in April (n=121 locations). Visits took place throughout the whole period, with readings generally in external walls and in ones that were wet and which then dried. Some walls were assessed as being largely dry and which remained so during the period, although their values have been included in any global analysis (so the average house drying rate will be lower as a result). Some walls appeared to start dry and then got wetter as the time went on. This may not be surprising, given these are surface readings, which could be affected by presence of salts, location of the probe relative to the materials and moisture in the walls. This just highlights the inherent difficulty in how to measure the wetness or dryness of a wall.



Figure 4. Distribution of samples in the study period (January, February, April, May). Location of sampling points (external walls, internal walls or unknown). Conditions at sample points (dry during the whole study period, dry at the beginning of the study period but wet later on, wet at the beginning of the study period; n = 375 sampling points located in 35 houses).

Figures 5 and 6 present examples of the data collected for two houses, showing the change in ambient conditions and moisture content from February to March. There is considerable scatter in the moisture readings at the various sampling locations (A to J), reflecting either redistribution of moisture during the drying process and/or the accuracy of the equipment used and the way it was applied. See Appendix 4 for an example of where the sampling points may be located in a house.



Figure 5. Moisture changes in property 2562.



Figure 6. Moisture changes as WME in property 2526.

In the above figures, 'Global' refers to the statistics for the whole house, which can be compared to those calculated separately for external or internal walls. It should also be noted that drying rates have been expressed as a negative change in %WME per day. Figure 7 presents the initial and final moisture values for each sampling point, again summarised on the basis of when the location was first sampled. So one can see a very slight decrease in the initial moisture from January to May, although very little difference in the corresponding final values. As one would expect, the external and 'wetter' walls show the biggest change in moisture level. The corresponding change in moisture content (drying rate per day) is shown in Figure 8. This again confirms that the largest changes are seen for external and wet walls, although interestingly, the largest drying rate (-1.55 %WME/d) occurs for locations that were measured from April onwards.



Figure 7. Initial and final moisture content at sampling points as wood moisture equivalent (WME) (mean + standard deviation; □, initial conditions; ∎, final conditions).



Figure 8. Moisture change (per day) at sampling points (mean + standard deviation) as wood moisture equivalent (WME).

This higher drying rate from April is also reflected in Figure 9, which shows the duration over which the readings were taken, and the average drying rate over this period. So the highest drying rates occur over shorter periods (10-30 days), whereas the houses that were monitored from January (50-70 days) have rates of about -1% WME/d. One interesting point from this graph is that even after 60 days, some sampling points are showing an increase in moisture, although this could be due to inaccuracy in the sampling probes.



Figure 9. Wall moisture changes (wood moisture equivalent, WME) as a function of the length of the drying period. (n=307, data from dry sampling points were excluded from the graph).

Looking specifically at the wet walls, Figure 10 presents the average drying rates based on all the sampling points. Figure 11 shows the average value for each house, which includes any 'dry' walls. These are not very different, as one would expect, and clearly show the higher drying rates in April and for external walls in general. This would seem to show the importance of the ambient conditions, with the higher spring temperatures helping to increase the drying of the external walls, and the house in general.



Figure 10. Wall moisture change in wet walls over the study period (mean moisture change + standard deviation; ■, wet walls in general; ■, internal walls; □, external walls). (n = 285, data from dry sampling points were excluded from the graph).



Figure 11. Moisture change (%/day) in flooded houses (mean moisture change + standard deviation; n = 35; ∎, overall house; ∎, internal walls; □, external walls).

Attempts were made to use the collected data to throw more light on the role of ambient air conditions in controlling the rate of drying. However, even though the relative humidity and temperature were recorded on most of the monitoring visits, this does not throw any light on what temperature and humidity was achieved during the forced drying periods. It is assumed that the ambient conditions were recorded following a period of 1-2 days when the drying equipment was turned off, in order to allow equilibrium moisture conditions to re-establish. Therefore the data only provide snapshots of conditions during the drying period, with the ambient conditions not reflecting the drying that had been achieved in the preceding period. Therefore you cannot deduce how the actual ambient conditions varied during the whole period and to what extent they might have helped or hindered the drying process.

In spite of this, physical theory would indicate that with warmer and drier ambient conditions, quicker drying of a property should be achieved, as long as there was good ventilation. The warmer conditions would also help to draw moisture from the external walls, at the same time as the internal forced drying was removing the internal moisture. This may well account for the higher drying rates from April, but the available data simply do not permit such definitive conclusions.

Finally, Table 4 gives the overall summary of the different drying rates, considering the houseaveraged values, and the wall-averaged values. In general terms, there is approximately a WME reduction of -1% per day, averaged for each house.

	House Global (% WME / d)	House Wet walls (% WME / d)	House Internal walls (% WME / d)	House External walls (% WME / d)	Wet walls In general (% WME / d)	Internal walls (% WME / d)	External walls (% WME / d)
January	-0.60 ± 0.35	-0.75 ± 0.61	-0.57 ± 0.63	-0.60 ± 0.28	-0.66 ± 0.71	-0.72 ± 0.81	-0.64 ± 0.68
February	$\textbf{-0.65} \pm 0.38$	$\textbf{-}0.79\pm0.58$	$\textbf{-0.39} \pm 0.69$	-0.74 ± 0.42	-0.73 ± 1.17	-0.45 ± 1.17	-0.78 ± 1.18
April	-1.53 ± 0.99	-2.34 ± 1.39	$\textbf{-0.58} \pm 0.50$	-1.65 ± 1.12	-2.37 ± 1.54	-1.38 ± 0.75	-2.48 ± 1.57
May	$\textbf{-0.80} \pm 0.26$	$\textbf{-0.96} \pm 0.30$			$\textbf{-0.98} \pm 0.58$		
Mean	-0.92 ± 0.74	-1.28 ± 1.15	-0.50 ± 0.60	-1.01 ± 0.84	-1.13 ± 1.34	-0.71 ± 0.99	-1.24 ± 1.44
Sample size	35	35	28	32	307	54	231

Table 4. Daily moisture changes averaged for flooded houses and wet walls.

Figure 12 gives the distribution of drying rates for houses, showing that most values lie in the 0 to -1.5% WME range. The corresponding distribution for each wall sampling point is shown in Figure 13. This illustrates how some walls gained moisture over the recording period, and so have positive values, with the general drying rate again lying in the 0 to -1.5% WME range.



Figure 12. Frequency histogram of house-averaged drying rates (n = 35).



Figure 13. Frequency histogram of wall drying rates (n = 375)

7.4 <u>Munters data</u>

Data for two houses from the Carlisle floods was provided by Munters. An example of the data sheets is given in Appendix 4. Tables 5 and 6 provide a summary of the drying rates and the use of energy.

	-		Initial condition	Final condition		
			(% WME)	(% WME)	Drying rate	
Structure	Materials	Ν			(% WME / d)	Properties
Wall	All	6	99.00	17.75	-1.05	16072, 16075
Wall	Brick-Exposed	3	99.00	19.16	-0.95	16072
Wall	Brick/Plaster-Exposed	2	99.00	15.25	-1.16	16075
Wall	Brick/Plaster-Paper	1	99.00	18.50	-1.12	16075
Floor	Concrete	2	99.00	20.00	-1.10	16075

Table 5. Moisture change and drying rates for selected flood-damaged structures and	
materials.	

Although one cannot draw many comparisons between these data and that from Rameses, the drying rates are roughly -1% WME/d, over a period of 72-84 days, consistent with the long-term values described above. In terms of energy use, the larger house requires almost double the amount of energy to produce a 1% WME reduction in moisture. Again, without additional data it is impossible to know if this is a real difference.

Carlisle	16072		Carlisle	16075	
Number of rooms:	4		Number of rooms:	3	
Total area:	72.5	m2	Total area:	60.0	m2
Time:	Feb-05		Time:	Jan-05	
Drying time:	84	days	Drying time:	72	days
Consumption:	9909.17	kŴ	Consumption:	5306.68	kŴ
Consumption per unit area:	136.68	kW / m2	Consumption per unit area:	88.44	kW / m2
Consumption per day:	117.97	kW / d	Consumption per day:	73.70	kW / d
Drying rate	-0.95	%/d	Drying rate:	-1.15	%/d
Consumption per unit			Consumption per unit		
of moisture loss:	124.1	kW / %	of moisture loss:	64.2	kW / %
Wall material:	Bricks, ex	posed	Wall material:	Bricks and	plaster,
				exposed	•
Floor material:	Concrete,	joist	Floor material:	Concrete,	exposed

7.5 HR Wallingford laboratory tests

Table 7 summarises the drying rates averaged over the internal walls, and the measured or extrapolated time to recover to the original moisture levels, based on the measured rate at ground level. As one would expect, these are lower than those achieved by the repair industry because they are natural rates, with no added input of drying energy.

Table 7. Drying times and ra	ates of walls teste	ed

Wall type	Average drying rate of internal wall	Time to recover original moisture levels*	Observations
	(% WME/day)		
Masonry, empty cavity			
External face: Engineering bricks	0 300	160 brs	Measured
Internal face: Concrete blocks	0.000	(approx. 7 days)	
Masonry, empty cavity			
External face: Engineering bricks	0 300	300 brs	Extrapolated
Internal face: Aircrete	0.000	(common 40 5 days)	
		(approx. 12.5 days)	
Masonry, empty cavity			
External face: Wire cut bricks	0.170	160 hrs	Measured
Internal face: Concrete blocks		(approx. 7 days)	
Masonry, empty cavity			
External face: Wire cut bricks	0.200	951 bro	Extrapolated
Internal face: Aircrete	0.209		
		(approx. 35.5 days)	
Masonry, empty cavity			
External face: Wire cut bricks	0.080	160 hrs	Measured
Internal face: Concrete blocks	0.000	(approx. 7 days)	
External cement render			
Masonry, part-fill insulation			
External face: Wire cut bricks	0.170	628 hrs	Extrapolated
		1	

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Internal face: Aircrete		(approx. 26 days)	
Masonry, mineral fibre full- fill insulation			Extrapolated
External face: Wire cut bricks	0.056	3764 hrs	
Internal face: Aircrete		(over 5 months)	
Masonry, blown-in full-fill insulation			Extrapolated
External face: Wire cut bricks	0.732	240 hrs	
Internal face: Concrete blocks		(10 days)	
Timber frame			
External face: Wire cut bricks	0.437	331 hrs	Extrapolated
Internal face: Concrete blocks		(approx. 14 days)	
Timber frame			
External face: Wire cut bricks	0.598	225 hrs	Extrapolated
Internal face: Concrete blocks (at ground level)		(approx. 9.5 days)	
External cement render			
Timber frame			
External face: Wire cut bricks	0.574	386 hrs	Extrapolated
Internal face: Concrete blocks (at ground level)		(approx. 16 days)	
External cement/lime render			

* Based on data collected at ground level on the internal face of cavity walls

7.6 Discussion

Although a limited data set, the drying rates from the two flood restorers are of a similar nature, with average rates being approximately 1% WME/day. If one ignores the higher drying rates, which are associated with houses that were monitored from April onwards, then the rates lie in the range 0.0 to 1.0 %WME/day. This is consistent with the rates achieved in the WP5 laboratory tests.

Figures 14 and 15 compare the rates and drying times for the three data sets. The WP5 data would appear to indicate quite rapid recovery of materials to their non-flooded state, but these were achieved in an exposed test rig, with natural ventilation of all exposed faces. Without

repeating the test for an enclosed test house, it is impossible to know how the natural drying would be impeded by the increased humidity in the property, which from above is important in reducing the drying rate. Conversely, the efficiency of the forced drying and energy use is impossible to determine; again utilising a test house could allow a comparison of the forced and natural rates, and the relative efficiency and cost benefits. Figure 15 presents the overall moisture loss at each sampling point and the time taken to achieve this. There is extreme scatter in these points, from which one can draw no clear conclusions. The general maximum moisture loss of about 80% that one would expect (100% down to c. 20%), can take anything from 15 to 90 days, according to these data.

Data published by Norwich Union on their Flood Resilient Home web site gives drying rates of 21 days (reducing to 14 days with resilient repairs), which whilst being achievable, do seem to be high compared to the general data from Carlisle. It has not been possible to determine where these figures came from. The conclusions from the WP5 report should be consulted as to which materials and constructions appear to dry the quickest. All the data from Carlisle refers to similar housing constructions (brick with or without plaster), and therefore it is impossible to draw any firm conclusions from it, in terms of impact of different materials.

Without a new, structured sampling methodology that the flood repair industry can use, it does not look as though there is a good existing evidence base to use to inform the WP9 guidance document. Therefore, this will have to be largely based on the WP5 laboratory results, which are at least derived from a consistent methodology and sampling regime. The field evidence supports the WP5 data, but does not help to provide any new insights, given the uncertainties over the impact of forced drying and ambient conditions.



Figure 14. Wall moisture changes (wood moisture equivalent, WME) as a function of the length of the drying period.



Figure 15. Wall moisture loss as a function of time

8. CONCLUSIONS & RECOMMENDATIONS

8.1 <u>General</u>

This report has included the views of a variety of organisations and individuals who are involved in the restoration of flooded buildings, and who as a result should have useful views on what would constitute resilient materials and constructions. In undertaking this series of face-to-face and telephone interviews, several new documents have emerged that may be of relevance; these have been published since the WP2 literature review (May 2005). Some of these have also been reviewed. A table has been produced in Section 6 that summarises the main views on what are Good practice and Poor practice in terms of resistant and resilient materials and constructions.

From the consultation undertaken for this work package it is clear that there is not a universal agreement on the definition of flood resilience. For example, contouring the ground around a house and raising floor levels are considered by some to be resilient measures, although this project (according to the outline in the WP4 report – Section 1.2) would consider them to be more flood avoidance or resistance. One has to accept that resilience comprises many aspects, including improving the repair and cleaning of a flooded property, reducing time for reoccupation, reducing costs and minimising health aspects. On a more basic level, this review has shown that one can consider resilience on two levels:

- That associated with the fixtures and fittings, and post-flood repairs (e.g. raising electrics, check valves on service ducts, raising appliances and units above flood level, using plastic/ceramic/steel fittings)
- That associated with the main fabric of the house (e.g. use of engineering bricks and render for lower 1 m of wall, use of close cell insulation, microporous coatings/paint). (Although some may consider that use of engineering bricks or external renders are 'resistance' measures).

The first type of resilience is the one that appears to have been promoted by several organisations over the past 5 years or so, and for which there are existing best practice case studies. The recommendations are common sense, and have been costed as to savings from future flooding. The same type of information appears in all of the documents reviewed, and takes the lead from 'Preparing for Floods', which responded to the 2000 floods.

Recommendations on building materials and construction approaches do appear in many of the documents, although it is not backed up the same level of technical evidence, and has not been used in many case studies. The FLOWS Cambourne house is one exception, although this has not been constructed in an obvious flood-risk area. This will not give much opportunity, therefore, to provide any real evidence on resilience. This example exemplifies the dilemma of consciously building a flood resilient house, expecting it to flood, versus the need to obtain primary data on how well various resilient measures perform under real flood conditions. The recommendation below for a test house facility, similar to that used by the Oak Ridge National Laboratories, is one response to this problem.

The continuing promotion of the first type of resilient measures, and the lack of hard evidence to support other options, has been concluded by the independent review of expert views and

new documentation undertaken for WP6. These findings accord with the conclusions of the WP2 review, and confirm the need for experimental data on the behaviour of materials and constructions (WP5). The majority of the current activity and emphasis remains in the flood repair arena, and not in the improved design and construction of resilient buildings.

A comparison of the drying rates from the laboratory test and a limited amount of field data has shown that these are in general agreement. However, it is very difficult to draw any firm conclusions, as to the behaviour of different materials or wall types, because the field data sets were so limited.

8.2 <u>Recommendations</u>

8.2.1 Resilient measures

Section 6 above has presented a range of views of good and poor practice in resilient construction, based on interviews and review of new guidance. This has been referenced back to what was found in the WP2 literature review and notes where views were based on hard evidence. Table 8 overleaf presents an overall summary of the main recommendations that come out of this work package. Some of the views expressed during the study did conflict with each other, and therefore the overall summary attempts to present the main areas of agreement. This table can be compared to the main outcomes from the WP5 testing.

8.2.2 Further research

The limited drying data has been analysed in as full a way as possible. It is considered that there is merit in pursuing this further, and therefore renewed attempts should be made to obtain additional data from the flood repair industry. This will confirm what is routinely collected, and what additional data would need to be collected to enable a better comparison to be made with the WP5 outputs. There would also be merit in trying to encourage the flood repair industry to undertake some more systematic data collection, to provide the types of information that are not currently available to researchers. Essentially, this would comprise a data collection checklist, along the lines of that already submitted to *Recovery* magazine. An alternative, and perhaps better approach, would be to obtain data through the conduct of some planned field trials, either in a laboratory form, with instrumentation in place, or by using a monitoring methodology that could be used rapidly in response to a new flood event. This would again be designed to take the right measurements with a good description of the field context.

To allow for a better comparison between the extensive laboratory data set that has been generated under WP5 and the field information, consideration should be given to the construction of a small test house, that would allow for drying rates to be measured that could be compared directly with the field evidence. In this way, more definitive statements could be made as to how different materials and constructions would behave in the real world.

Finally, although there appear to be few examples of flood resilient homes, or even retro-fitted ones, effort should be made to try to collect any evidence of how they had responded under a real flood event. In terms of future work, it would be useful to consider ways in which the properties could be monitored for future flood events, or at least have a data collection

protocol that the homeowner could fill in as soon after a flood as possible. Only by recording such information can the performance of resilience or other measures be properly assessed.

Good practi	се					
Construction type	Feature	Mentioned in guidance?	Recommended by	In use?	Tested in WP5?	Comments/recommendations
General	Move power sockets above flood level	1, 2, 3, 4, 5	Munters	FLOWS	X	In WP2 report
	Control valves on ducts etc.	1, 2, 3, 4, 5		FLOWS	X	In WP2 report
	Ground contouring and raising cill levels	2, 4, 5	HBF	FLOWS	X	In WP2 report
Walls	Sand/cement render	2, 4	Munters	FLOWS	1	In WP2 report (some technical evidence). Need to look at drying properties
	Lime plaster	1, 3, 4, 6	Belfor	FLOWS	V	In WP2 report. Issue of whether it would be appropriate for new build, due to curing times and specialist application. Need further testing to determine minimum curing time
	Water-resistant paints and coatings	3, 4			X	Evidence in WP2 report from USACE tests that show some coatings may not be robust. Further testing is recommended
	Engineering bricks	6	Belfor	FLOWS	V	
Insulation	Closed cell foam in cavities	1, 3, 5, 6	Belfor		1	In WP2 report (some technical evidence)
	External self-draining mineral wool batts	3, 4			X	External polystyrene insulation was tested as part of WP5 Stage 4
Floors	Facilities to pump out basements	5	Belfor, NFF		X	In WP2 report

Table 8. Main findings from WP6 for resilient measures

DCLG BUILDING REGULATIONS (SANITATION) FRAMEWORK

	Ceramic tiles, skirting	3, 5, 6		FLOWS	Х	In WP2 report (some technical evidence)
	Suspended or solid concrete floor	2, 3, 4, 6	NHBC		N	
Fittings	Steel or plastic units	1, 2, 3, 4, 5		FLOWS	X	
	Appliances raised on plinths	2, 3, 4		FLOWS	X	
Poor practic	e	L	<u> </u>		1	
Construction type	Feature	Mentioned in guidance?	Recommended by organisations	In use?	Tested in WP5?	Comments/recommendations
Walls	Gypsum plasterboard	1, 2, 4, 6	Belfor, Munters	-	V	In WP2 report (some technical evidence). But may be acceptable if lay horizontally and accept that it will have to be replaced
Floors	Chipboard and laminated floors	1, 2, 3, 4, 5, 6	Belfor, Munters	-	√	Although chipboard was not tested by WP5, the results for OSB, which is another type of particle
						board, can be taken as fairly representative

Repairing your home or business after a flood – how to limit damage and disruption in the future, ABI and NFF
Design Guidance on Flood Damage to dwellings, Scottish Office
Repairing flooded buildings, Flood Repairs Forum
Preparing for Floods, ODPM

Flood Resilient Home, Norwich Union
Planning Advice Note PAN 69 – Planning and Building Standards Advice on Flooding, Scottish Executive

9. **REFERENCES**

- 1) "Making Space for Water. Update Newsletter", Defra, July 2006.
- 2) "PAS 64 Professional water damage mitigation and initial restoration of domestic dwellings", BSI, May 2005
- 3) "Preparing for floods. Interim guidance for improving the flood resistance of domestic and small business properties." 2003 Reprint, ODPM 2003.
- 4) Planning Policy Guidance Note 25 (PPG 25) "Development and flood risk". DTLR 2001
- 5) "Repairing flooded buildings", Flood Repairs Forum, 2006
- 6) "Repairing your home or business after a flood how to limit damage and disruption in the future", ABI and National Flood Forum, 2006
- 7) "Standard for the repair of buildings following flooding", CIRIA, 2005.
- 8) "Sustainable Drainage Systems for New Homes Best Practice Guidance. Showcasing Sustainable Drainage and Flood Resistant Building Construction", Royal Haskoning, June 2006.
- 9) Improving the Flood Resilience of Buildings through Improved Materials, Methods and Details. "Report Number WP2c – Review of Existing Information and Experience (Final Report)", J. Wingfield, M Bell and P Bowker, June 2005.

www.floodresilienthome.com

www.nationalfloodschool.co.uk/isd mw pas64.htm

APPENDICES

APPENDIX 1 SUMMARY NOTES OF MEETINGS/DISCUSSIONS
1. HR Wallingford meeting with Mike Waterfield (Munters/BDMA)

16th February 2006

Restoration procedures

MW explained general principles of how flooded properties are restored:

- Munters use laptops on site to record information, which then goes into their database (only company to use such a comprehensive electronic database)
 - Make assessment of damage
 - o Decontaminate
 - Then dry out estimate drying time based on moisture content of walls/ceilings and ambient conditions
- Use a Protimeter (GE Protimeter, Marlow) to measure WME (wood moisture equivalent) of surface materials (using two sharp probes, or a sensor on the back). Use hygrometer sticks to measure RH in brickwork or similar materials.
- Also use a long RH (relative humidity) probe for in cavities (manufactured by Vasala); a calcium carbide device ("speedy moisture meter") which is used with a weighed sample of material, and which gives off an amount of gas in proportion to the amount of water present – use for concrete/brick samples.
- Property will be visited every couple of weeks (10-15 days) to check on drying process.

In summary, steps are:

- Reconnaissance survey
- Decontamination
- Strip out materials if necessary often completed by building contractor
- Sanitise
- Dry out.

Removal of materials all depends on how wet they are and how long the water was allowed to 'affect' them.

In flood situations restorers' advice about what should be kept or ripped out is ignored or not even asked for – this is down to the Loss Adjustors and the policy of the insurance company – normally surveying company and builder agree stripping out and reinstatement.

Plaster would normally be removed, and plasterboard taken off to 300 mm above the original flood level - dependant upon the type of construction and practical methods for making good.

Moisture behind plaster is difficult to dry out.

Sand/cement render is good at letting water out.

When property is 'dry' (i.e. back to pre-incident conditions) then there will be re-instatement on a 'like for like' basis, but this depends on the policy holder and the loss adjustor.

BDMA members would typically be following the procedures set out in 'Standards for the repair ...' (CIRIA).

MW's initial thoughts on resilient designs

- Avoid laminated floors
- Have furniture etc. that can be easily moved
- Power sockets at high level
- Avoid insulation in cavities if possible.

Munters' database system

This is an internet-based system ('SimplyConnect.NET'), which uses 'CRYSTAL' reports. It has been set up by a 2-man software company, who are providing a dedicated service to Munters, and who are occupied full-time in providing updates and new functionality to the existing system.

For each case study, there will be readings for each visit, comprising ambient and moisture readings in each of the affected rooms, although ambient conditions may only be recorded during the first visit (based on the examples viewed during the meeting).

The information may not provide details of the duration of flooding in the property, although there may be some useful information in the 'Occupier's notes'.

Based on the discussions at the recent BDMA Executive meeting, when our data needs were raised, it appears that many of the restoration contractors only have paper records, and there was concern/doubt over how useful it would be to analyse all of the information. For earlier floods, such as Lewes and Northampton, Munters only have this information in paper records, which are stored at their Huntingdon archives.

MW provided two case study examples, minus any customer details, so that HRW can assess the usefulness of the information and what would be involved in analysing it.

Andy Tagg set out what he thought was needed in terms of progressing this work element (for the Munters' database), according to the agreed specification for WP6:

- 1. Obtain example of the data/information
- 2. Determine what is most useful information, so that we can restrict the database queries
- 3. Agree with Munters what information we want and that it can be given (we will need to provide a formal request to Munters, who in turn will have to check this with the insurers, as they are ultimately the data owner)
- 4. Write a CRYSTAL report for the above agreed information
- 5. Run the CRYSTAL report to extract the information into a suitable form (spreadsheet).

MW stressed that Munters would not be happy for anyone else to access their information, and that he was concerned over taking up valuable time from their software specialist to produce these additional queries/reports.

MW also noted that the Insurers or Munters' Directors may not be happy to release this information to the project and that this could be the case for other restoration contractors.

Other contacts

MW provided details for other BDMA members for HRW to contact:

- 1. Bob Spencer Rainbow International (Mansfield) 01623 675100
- 2. Neil Courtney Belfour (Milton Park) 01235 862550
- 3. Adrian Jolley (Simon Ford) Chem-Dry (Beverley) 01482 872770
- Names in italics were present at recent BDMA meeting and are aware of our data request. Firms 1 and 3 carried out most of the work after the Carlisle floods.

2. Meeting with Belfor

Milton Park, 3rd March 2006

Present: Laurence Mitchell (Belfor)

Neal Courtney (Belfor – for initial scene-setting)

Andy Tagg (HR Wallingford)

- 1. After an initial explanation of the flood resilience project from AT, LM explained that all flood restorers are under pressure to dry the property as quickly as possible, therefore they don't have the luxury of looking closely at how it was flooded etc. They are also under pressure to minimise monitoring visits, and therefore Belfor does sometimes use remote monitoring, with drying equipment being left in place. However, the problem with this is that householders can then turn off the equipment, and therefore the drying does not go according to plan.
- 2. LM identified 5 different types of property, and that Belfor would use appropriate drying methods for each type, depending on the nature of the flooding. The most common types of wall and floor constructions encountered are:
- brick cavity (with or without insulation)
- stud walls with plasterboard (with or without insulation)
- timber framed (with or without insulation)
- solid walls (stone)
- plaster and lath
- floating floors
- suspended timber floors
- solid concrete and screed.

Drying methods include:

- injection drying using positive and negative air flow into cavities, voids and under floors
- surface evaporation air movement using positive and negative air flow
- direct radiant heat to cause evaporation in solid materials (brick, stone masonry, concrete)
- convectant drying for all materials (without vapour barriers)
- dehumidification
 - a. condensation type for class 1 (porous) and class 2 (semi-porous) materials, and indoor air parcels
 - b. desiccant type for specialist drying below 15 C, for class and 4 (non-porous), cavity drying and indoor air parcels where RH is required at a drier condition

Tented drying systems are used to isolate wall, ceilings and floors to concentrate on the wettest areas that need mechanical assistance. This involves constructing a tent or

canopy of thick gauge polythene or plastic which has a low permeability so as not to allow moisture infiltration unless it is required for the drying process for air exchange.

- 3. Belfor deal with a lot of water damage, although it has to be recognised that tank or pipe leaks can do more damage than a flood it all depends on the actual circumstances of where the damage took place and for how long the property was affected. A burst tank could result in a house being 'gutted', whereas 1 foot of floodwater is a lot easier to deal with.
- 4. Walls obviously give some form of protection against flood waters it all depends on the building construction and how well sealed are the building components. So uPVC doors are very good, with water coming in from the seals or brickwork.
- 5. LM's experience of rendered buildings is that whilst floodwater is kept out, there are problems with condensation if they get flooded inside the render doesn't 'breathe' as well as the original wall.
- 6. Discussed structural issues, and how they will restrict the pump rate from flooded cellars and basements, so as not to have water levels inside and out that are too different.
- 7. Belfor will try to find out when the property was flooded and how long the water was in there, to help in their diagnosis. Removing moisture is the easy part; finding where the moisture is can be more of a challenge. Contamination can also be a problem, with silt, oil and pesticides trapped in the cavity or pores of the building materials.
- 8. BDMA members will recommend to the owner/loss adjustor what should be done, and what is beyond restoration, such as damaged wood and plasterboard. Typically they will explain to the loss adjustor the benefits of removing materials, such as that it will reduce the drying time and hence cost. Belfor may remove some materials, or this could be down to the repair contractor.
- Issue of lime plaster was discussed, and LM agreed that it is good at letting moisture out – referred to as 'renovating plaster' – but it is important that the owner doesn't decorate the wall as this reduces the benefit (the appearance of this type of plaster is such that decorating over is not required for aesthetic reasons).
- 10. LM considered that 'resilient' materials were ones that survived better, or were easier to replace.
- 11. Discussed problem of cavities, and how water can get in and move up the inside of the bricks. A brick will be removed and an endoscope used to see what has happened inside. To remove material this can be either powered washed to liquefy the silt, or it can be allowed to dry out and is then vacuumed out dry. Normally, properties take 6-8 weeks to dry out to acceptable levels.
- 12. Discussed drying out of insulation in brick-built cavities. This can be 'float-dried', using high-velocity forced drying at the top and bricks removed at the bottom so that the moisture can escape where vapour pressures are lower. If the insulation has been damaged, then in some houses this can be removed from the upper floors. Solid expanded polystyrene maintains its shape, by letting moisture through it, but does take a long time to dry. LM considered that this type of insulation was good, if it could be completely covered in waterproof material, so that no water could penetrate. This would then maintain the insulating/noise properties, and would remain dry, assuming the waterproof covering did not get damaged in construction.
- 13. Discussed merits of different floor types. Solid wood floors are OK if they are pressuretreated and have a large void underneath for water to move up and down. They are easier to restore and only badly deformed parts may need replacing. Laminate floors are not so good, as the paper photocopy and paper filler layer are the ones that degrade when wet. If these could be made of solid plastic, then it would not be affected by water damage.

- 14. LM noted that they use PAS 64 as their guide for flood restoration, which covers the whole process. The first two stages (decontamination and drying are covered by BDMA members).
- 15. In terms of equipment, Belfor use the same items as Munters (Protimeter, Calcium Carbide meter, IR camera). In addition to taking moisture readings in the wetted areas, they will also take readings above the 'tide-line'. When WME is 16-19% it is classed as 'dry'. Normally, they would dry for 7-14 days, and then have a second visit to carry out a full moisture survey to identify the 'hot spots'. Small holes are drilled into the building fabric and insulated deep wall probes are inserted to check how deep the moisture is. Home owners will be asked to turn off the driers for 24 hours before the 2nd visit, so that the moisture can return to a stable or "equilibrium" distribution
- 16. Plasterboard can dry out quite well, so it may not need to be removed. The problem is when it gets contaminated, in which case they would remove 300mm above the tideline. LM mentioned this issue from the USA of toxic mould, which produces harmful spores.
- 17. In trying to produce a good diagnosis of the flooding problems, there is the issue of whether they will be allowed to undertake any invasive surveys, to check on the actual amount of wetting and/or contamination.
- 18. Discussed role of remote, dial-up equipment, which could save money from reducing the number of visits. However, this is not fool-proof, and it may be the case that the equipment does need to be moved to dry other parts of the property, so in the end the drying could take longer.
- 19. Discussed benefits of different types of bricks, and their attributes. LM agreed that engineering bricks are good at restricting water, but if they do get wet (say from vertical movement on to the top), then they will take a long time to dry out, compared to more porous bricks. Engineering bricks are used, but mainly up North (Rotherham, Sheffield, Doncaster) and for houses that are 100-150 years old. In Carlisle, 4 different types of brick had been used, with different ingredients. Some of these looked wet, but were actually dry. Temperature also important in how the bricks retain moisture.
- 20. LM thought that materials should be used that allow 'open-drying' hygroscopic materials that will dry quickly (e.g. includes wood, plaster, plasterboard and brick)
- 21. LM agreed to send an example of the type of data that Belfor collects on flooded properties, so that AT can assess how it can be used in the project. He didn't foresee any problems in this information being made available to the project.

Andy Tagg

6/3/06

3. Notes of Meeting held at H R Wallingford, 31 March 2006

between representatives of the Flood Repair Network,

Rameses Associates and H R Wallingford

Present:

David Ramsbottom - HRW Project Director, Flood Resilience

Andrew Tagg – HRW Project Manager for ODPM Building Regulations (Sanitation) Framework

Pam Bowker – former HRW Project Manager as above

Manuela Escarameia – HRW Principal Engineer

Professor David Proverbs - Flood Repair Network Chief Investigator

Roger Woodhead – Director of Operations, Rameses Associates

Carly Rose – Flood Repair Network Project Administrator (Notes)

Item	Action	Action by
Introductions and Purpose of meeting	The scope of both projects was discussed and there was general agreement on the potential for synergy.	
	The research on the DryAir system being carried out at Sheffield Hallam university was also discussed in some detail.	Info
	HRW will make contact with Barry Mathewson (details provided by RW).	RW
	Rameses will contact HRW when a suitable site for field trial presents itself.	

Item	Action	Action by
Overview of testing programme & outputs	The current test results were discussed in detail and RW reported broad agreement as found in field situation.	Info
Activities of UoW, FRN and Rameses	Details of the 'Fermacell' plasterboard, recommended for bathrooms/kitchens to be supplied to HRW.	RW
	The National Flood School facility, founded by Chris Netherton, was discussed in particular their links to the IOSRC in USA. Details to be provided to HRW.	RW
Data/information requirements for Work Package 3	Cost values of flooding in the context of flood resilience measures - Jamie Garbett at Rameses to be asked for data derived from the Carlisle floods	RW
AOB	AT accepted an invitation to speak at the FRN workshop on 12 September 2006 in Sheffield. May be in association with Malcolm Bell (Leeds Met. university). Further details to be discussed with AT.	DP
	The possibility of HRW utilising this event as a platform for consultation on the guidance document was discussed and agreed in principle. Liaison needed.	AT/CR

DCLG BUILDING REGULATIONS (SANITATION) FRAMEWORK

Item	Action	Action by
	HRW was invited to host the March 2007 FRN workshop. This was agreed in principle. Further details to be provided.	CR
AOB (cont'd)	The international FRIAR conference in London (21/22 April 2008) was highlighted.	Info
	AT to be included on FRN mailing list	CR
	Possible cross-linkages between FRN and HRW websites to be examined.	
		AT/CR
	Norwich Union have created a flood resilient house in Lowestoft, Suffolk – were the BDMA/ Neal Courtney involved in the project?	
		CR
	Data re drying time & techniques to be requested from Rameses for HRW's use	
		RW
	FRN website to include article on this meeting	CR

4. Meeting with Mary Dhonau (National Flood Forum)

Bewdley - 15th May 2006

MD mentioned a flood resilient new build project being run by RIBA – she had been contacted at the end of 2005.

MD suggested that we should speak to Simon Hughes (EA), since he is leading the MSfW work on flood resistance/resilience

MD thought that a visit to the National Flood School (Chris Netherton) might be useful

MD mentioned the FLOWS final conference coming up on the 27-29 June in Cambridge. (Contact is Sheryl French 01223 717085 – FLOWS PM)

MD suggested speaking to Paul Hendy (01228 625567) about people's experiences in Carlisle. AFT had heard his talk at the FloodRepairNet conference in Telford.

MD mentioned Andrew Arrol (Arrol & Smith Ltd.), who is an architect and is currently undertaking work on York Minster. Could be worth speaking to re: resilient designs.

MD noted that Ron Whitehead (Flood Protection Agency) could have some useful information on flooding of specific properties.

Ideas for resilient designs

- Tanking of basement and moving services higher this had had a major benefit in reducing MD's flooding problems (in Worcester due to inadequate drainage)
- People seem to take about 4 floods before they decide to invest in flood resilient repairs (comes from comment from Jill Boulton at NU, I believe)
- One firm proposed an impervious membrane down the wall, which does help with the drying and repair of the internal walls, but does trap water behind it in the cavity, and so will tend to impair drying
- Agreed that external render had a big benefit in keeping water out
- Mentioned that lime plaster was good at recovering from a flood

MD highlighted major issue of water coming up from underneath the property. Therefore the use of sumps and pumps was a common mitigation option, and the need to raise plug sockets. Concern had been expressed by some people that keeping water out could cause a pressure build-up and that water could break through the concrete.

Noted that Sebastian Catovsky was a mine of information, and probably should be contacted.

NFF have a conference on the 23rd September in Bradford. Jane Milne will be speaking? Need to check NFF web site for further details.

MD mentioned MSfW project on flood resilience, and the issuing of grants to promote this.

Peter Jones at Welsh Assembly may be worth contacting over their initiatives.

Dave Melling in Bradford – flooding local action plans

Finally, noted that FLOWS had intended to build a flood resilient house, but they had only retrofitted this to a house in Lowestoft. (Mentioned this to Jill Boulter at NU, who seemed to imply this was all they were planning to do). MD thinks they may try to do this in FLOWS2 – we should try to get involved in this is at all possible.

MD gave me a copy of a new factsheet produced by ABI and NFF – '*Repairing your home or business after a flood* – *how to limit damage and disruption in the future*'.

5. Notes of telecom with Jill Boulton, Norwich Union

16th May 2006

AFT asked about where drying times had come from, that were mentioned on the 'Flood Resilient Home' web site of NU. JB thought they had come from CIRIA. (*AFT to follow up with CIRIA*)

JB mentioned the CIRIA workshop held in 20 September 2005 on 'Post-flood repairs'. (*Is this where the data was mentioned?*)

JB mentioned that Halifax have recently commissioned Andrew Black to update the Dundee Tables, which give costs of repairing after a flood.

JB mentioned retrofitted house in Lowestoft, as part of FLOWS project. She indicated that this was what they had intended to deliver for FLOWS, and not to build a new resilient home, as Mary Dhonau had thought. JB thought it not worth going to see the house, as photos on web site gave a good idea of what had been done.

NU funds an all-party group in Parliament, to lobby and raise issues relating to flooding and costs of repair etc. Agreed that lobbying also needs to be directed at developers.

Noted that PPS25 will say that homes should be flood resilient, and that where properties do not have the 1 in 75 year protection, then these will be referred to an underwriter, to assess the reasons for this, and if there is a flooding problem. If NU is convinced that a home is actually OK, within the 75 year outline, then they will provide insurance.

NU has undertaken research on customers. Seems to indicate that it takes 4 lots of flooding, to get them to accept that flood resilient repairs are worthwhile and cost-effective.

JB mentioned David Fakeney of SEPA (Perth) as a contact. He is the Flood Warning Manager. Also thought that Gill Holland (Tewkesbury) would still be wroth contacting, even if no longer working for NFF.

JB thought that telescopic airbrick covers were an obvious winner, especially to prevent flash floods entering a house. Also, noted problems associated with GW flooding, with water entering from under the floorboards.

APPENDIX 2 SUMMARY OF REVIEWED DOCUMENTS

1. PAS 64 – Professional water damage mitigation and initial restoration of domestic dwellings (May 2005)

Published by BSI, and authored by the Nethertons of the National Flood School. Code of practice – in form of guidance and recommendations, not a British Standard.

Goal is to return properties affected by water damage to a pre-loss condition, unless this is not possible. May require an individual approach. Water Damage Company has grown from a myriad of professions.

Applicable to all forms of water damage.

Need for proper Management and H&S procedures.

Operational procedures

- Loss mitigation
 - Protection of materials
 - Initial water removal (eliminate or contain water ingress, remove to limit damage to smallest area possible)
 - Controlling micro-organisms and contamination (as above)
- Drying
 - o Establish drying goals
 - Schedule of works
 - Completion
- Cleaning
 - Cleaning goals
 - Schedule of works
 - Testing (optional)
 - Completion.

Drying

- Materials removed if beyond saving
- Barriers to evaporation removed
- Moisture content assessed
- Method statement for drying
- Drying goals set for affected areas (based on reading in unaffected areas)

Monitoring

- Specific humidity in air
- Equilibrium relative humidity in solid materials (e.g. plaster, brick)
- % moisture content in hard or soft wood
- Relative moisture content should be used if invasive testing would result in further loss or is impractical

Cleaning – follows similar pattern to drying (can use ATP or swab methods to check that cleaning goals have been achieved or set correctly)

Issues

• Drying – construction type, age, materials, amount of water and time in property, contamination

2. 'Repairing flooded buildings' – Flood Repairs Forum (2006)

Aim – collation of all knowledge to inform best practice for the repair, mitigation and prevention of flood damage.

Aimed primarily at insurance industry and related bodies.

Remediation team – RICS, BDMA or CILA. Need knowledge of:

- design and construction methods
- effects of water on buildings
- drying methods
- reinstatement techniques.

Issue of when a property is sufficiently dry to allow repairs to commence – doesn't need to be 'bone-dry'. What needs to be removed to assist the drying (e.g. wallpaper, plaster, flooring).

Heat, *per se*, can have a deleterious effect on materials if maintained at a high level for too long. If too dry, can become brittle or cracked.

Reduction in moisture content of wood to 20-22% within 3 weeks is important in preventing rot. Ventilation is important.

Insulation – may have to be removed or dried *in situ*. Depth of standing water may not be a good guide to level of moisture in the fabric.

Mould – normally commences after 2-3 das after building becomes wet. If moisture removed quickly, mould should not be a problem.

Guide to drying

Drying standards	- back to pre-flood conditions
	- moisture will not support mould and mildew
	- levels of trapped water will not migrate and cause damage
	elsewhere
Cleaning	- no attempt should be made to dry the building until all wet
	cleaning has taken place
	- consider removal of perimeter skirting boards in case these
	press against walls
Drying methods	- dehumidification
	- convection

- heat transfer
- heat exchangers
- vacuum drying
- 'open and closed' systems.

Refrigerant dehumidifiers – energy extracted is less than that input, so have a good coefficient of performance, work OK in 60-98% RH.

Desiccant dehumidifiers – silica gel, have two zones to remove moisture and then use warm air to take it away, work OK in 40-90% RH.

Convection drying – uses air movement, raised air temperatures, low moisture content, all with continual air changes. Use warm, drier air to replace wetter air, and take moisture away before it can condense on other surfaces.

Drying programme – depends on moisture content of materials, permeability, moisture barriers. Need to combine dehumidification with air movement and heating. Need to decide on what equipment to use and how many units. Monitoring programme will provide valuable information on how well drying is going, and what changes might be needed. Ideal drying at 40-50% RH and 18-23 °C.

Need to look for trapped water, in insulated floors or in cavities. Surface coating and impermeable membranes can all slow the drying process.

Monitoring

Hygrometers – measures T and RH. Use them to ensure that optimum drying conditions are achieved. RH below 60% should avoid mould growth.

Resistance meters – many types, more moisture, higher conductance.

Calcium carbide meter – sample taken by drill and weighed, then calcium carbide powder added and unit sealed, gas given off gives % moisture content of wet weight of sample.

CIRIA - Report 'A review of testing for moisture in materials'.

Resilient repairs

Follows guidance in ODPM 'Preparing for floods' (2003).

External walls (finishes) – consider entrapped moisture beneath impervious coatings. Consider microporous coatings as resilient repair.

External walls (structural) – consider water resistant coatings to 500mm above flood line. Cavity fully sealed where air bricks and services penetrate walls. Consider types of insulation. Timber frame – consider reconstructing with traditional materials and methods. This advice may be difficult to follow in practice as some of the most vulnerable parts of timber frame are within the cavity construction. **Insulation** – consider closed cell insulation foam, rather than blown fibre. Could get corrosion of wall ties and insulation fixings on mineral wool batts. External insulation – check corrosion, contamination, entrapped moisture. Internal insulation – probably have to remove – look at low absorption insulating boards, or self-draining mineral wool batts.

Internal finishes – water-resistant render and lime-based plaster or hydraulic lime coatings. Tiles – use waterproof adhesives and grout. Paints – microporous paints. Wallpaper – avoid vinyl wall coverings.

Floors – vinyl flooring and quarry tiles generally OK, but may need replacing. Solid or suspended concrete floors – OK but consider replacing services. Suspended timber floor with chipboard or softwood floorboards – consider replacing with solid floor. Oak blocks or hardwood block – consider screed and floor finish.

Joinery and fittings – kitchen and bedroom units – consider PVC-U or building off floor with plastic legs. Skirtings etc. – hardwood or PVC-U.

Reposition electrics, gas and water boilers above flood line.

Insurance – ABI confirmed that additional cost of resilient repairs does not fall on the insurer, who only has an obligation for cost of standard repairs.

Susceptibility of buildings and fittings

Concrete can absorb large amounts of water, and produce chemical reactions and fungal growths.

Cavity insulation can deteriorate if gets wet.

Floor membranes can trap water like a reservoir, causing damage to flooring materials.

Chemical action of salts can affect brickwork and compromise DPC.

Silt in cavities can render DPC ineffective.

APPENDIX 3 INFORMATION PROVIDED TO RECOVERY MAGAZINE

Information request to BDMA Members

HR Wallingford is part of a consortium, led by CIRIA, which is investigating the flood resilience properties of building materials, constructions, designs and details. The project is funded by the ODPM and the Environment Agency, and it aims to produce new guidelines on more resilient designs for new properties. Resilient in this context means able to withstand being flooded, and easier to clean, dry and restore.

HR Wallingford is undertaking a series of laboratory tests, looking at the seepage/leakage rates through building materials, walls, floors, and eventually some innovative designs. We are also looking at how all of these materials dry out, plus recording damage to insulation etc. As a separate work package, we have been asked to identify and obtain as much useful information from the 'real world', to compare with our lab results, so that when we come to produce the new guidelines on improved flood resilient approaches, we can base it on all relevant data. One of the key organisations that can help in providing this information is the BDMA, and meetings have taken place with two affiliated companies, and the data request was discussed at the BDMA Executive meeting on the 31st January.

The following table provides a simple matrix for the type of information we are looking to collate and analyse, based on the meetings held so far. However, any information that you consider relevant should be provided, whether quantitative or qualitative. In summary, we are looking for hard technical data (e.g. how the moisture content changed in the walls and floors during drying), in addition to qualitative assessments/views on which materials appear to survive best under flood conditions, which are more prone to mould growth etc. In order to restrict both your efforts, and the time we would need to analyse any information, can you please provide information for only major floods (excluding sewer flooding), that have occurred over the past 5-6 years (i.e. so as to pick up the 2000 and Carlisle floods). We believe that the easiest method for you would be to extract the data from your existing databases, and to output the relevant fields (as set out in the Table below) into Excel. However, if this is not possible, then we could provide you with a blank spreadsheet, that you could then fill in by hand.

If you need further information, or would like to discuss this request, then please contact Andy Tagg from HR Wallingford (01491 822332 (T), 01491 825916 (F), aft@hrwallingford.co.uk).

DCLG BUILDING REGULATIONS (SANITATION) FRAMEWORK

Type of property:	When flooded:
Location: (e.g. Carlisle)	Duration/depth of flooding:
Summary of visits:	Dates, notes, observations
Visit 1:	Room 1:
	Area
	Ambient conditions
	Moisture content (surface, in material, in cavity)
	Type of wall/floor construction, finish
	Condition of walls at ground level. 0.5 m and 1.0 m (integrity, mould growth etc.)
	Room 2:
	As above etc.
Visit 2:	Room 1:
As above etc.	
Equipment used:	How long to dry out:
	Total hours
	Total kWh
Other notes on flooding incident:	
e.g. where flood came in	
what had to be removed/replaced	

DCLG BUILDING REGULATIONS (SANITATION) FRAMEWORK

NB. Information is to be entered in cells coloured

Location of property e.g. Carlisle)			
Type of property			
looding details:	When flooded		
	Duration of floodin Depth of flooding	ıg	
ummary of visits:	No. Date	Notes	Observations
	1 2 3		
eit dotaile:	etc.		
No.	Room N	lo. 1	
1	Area		
	Ambient	t ns	
	Moisture	e content	
	Location in mater	n (surface, ial, in	
	cavily)	well/floor	
	finish	stion &	
	Conditio (integrity growth e	n of walls γ. Mould etc.)	
		at ground level 0.5m above floo 1.0m above floo	or or
No			
2	Room N	lo. 1	
peat for each visit	Area		
	Ambient	t ns	
	Moisture	e content	
	Location in mater cavity)	n (surface, ial, in	
	Type of construc finish	wall/floor ction &	
	Conditio (integrity growth e	n of walls /. Mould etc.)	
		of many lines in the second lines of the secon	

APPENDIX 4 EXAMPLES OF DATA SHEETS FROM RAMESES AND MUNTERS

2	È		1	U	W			CDN		25838			SHI	EL:	-			
L		() ()	Ŋ	N				INSC	JRED:		KEATS		-					
DAMAGE MA	NAGEME	BUILT SNT SP	ON REPU	TATION ISTS				ADD	RESS:		153 GRI	EYSTOI	NE RO	AD, CAR	IISLE			
Date: 27. la	n Relative I	Humidity	75.5	700			Intern			C°C			Г					
Point	A	B	0			ш			Н Н			-	×	F	2	A		-
Moisture Reading	1000	100(350	1000	100	2	50	900	1000	970	10	00			Γ	0,	94%
Date: 04-Fe	b Relative I	Humidity	21	%2			Intern	al Air Tei	mp: 22	5°C			Г					
Point	A	В	0	0		ш	ш	U	I			٢	×	F	2			
Moisture Reading	612	923	10	000	610	74	5 7	06	745	250	540	6	80			T	7	72%
Date: 11 Eo	h Polotiva I	- Himidity	L L	207			Intorn	I Air To.	1	C°r			ſ]		
Point			5 (ſ				11p. 12				2	ŀ				
Moisture Reading	790	65C			560	ď		D Ca	L CS		JUC	2		-	2	A	>	/00
		5	,	200		30		00	noc	200	2012	Z	n	-			0	0%70
Date: 23-Fe	b Relative F	Humidity:	2	4%			Intern	al Air Ter	np: 18	.2°C			Г					
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Moisture Reading	200	006	2	00	250	100	0 10	00	650	190	200	2	10	┝		Γ	4	8%
Date: 16-Fe	b Relative I	Humidity:					Interna	al Air Ter	.du]		
Point	A	В	U			ш	ш	U	I			P	¥		2		>	
Moisture Reading	170	230	1	80	180	96	0 10	00	825	180	190	2	00		T	Γ	4	%0
Date: 29-Ma	IT Relative F	Humidity:					Interns	Air Ter]		
Point	A	В	U				LL	U	I			-	×	F	2		>	-
Moisture Reading	167	210	-	80	180	53	0 5	50	190	180	180	4	00	-			5	5%
														Lloy	ds TSB]		



e

Completed Visits

Visit Date and Time 07 April 2005 12:30 09 March 2005 15:00 25 January 2005 14:00 Technician who attendedAngus CouperMAndrew IretonM

Danny Brogan

Mobile: 07786172744 Mobile: 07786708834 Mobile: 07786708839

Future Visit(s) booked

Currently assigned visit date and time

Currently assigned Technician

Mobile:

Survey Summary as on 07 April 2005

Currently 3 room(s) affected with a total area of 60.00 square metres. 17 reading(s) taken. 07 April 2005

Moisture levels have now returned to pre-incident condition

09 March 2005

Installed extra peice of equipment to help with drying process Property drying well made Dave Jones PCC @ Halifax awgre of concerns with insulation in cavity.

25 January 2005

I confirm cause of damage is as per original instruction. Installed equipment to start drying process

The latest estimated completion period is 6 week(s) and the insurer damage type is Major Flood.

Survery Summary for 16075: 17 Morton Street, , CARLISLE, , CA2 5UU

Page 2 of 4

Actions required by Loss Adjuster/Claims Advisor

Appointment Instructions Date

Detailed Survey as on 07 April 2005

Entrance hall 1 (total area: 8.00m²)

Ambient Reading(s):

25 January 2005 - 74 RH(%) - 11 Temp (°C)

Position: Wall Type: Brickwork-solid/with plaster Finish: Paper

Reading(s):

25 January 2005 Surface: WME (%) 99 Surface

9 March 2005 Indepth: WME (%) 19-30 In-depth 10(mm) 7 April 2005 Surface: WME (%) 18.5 In-depth 20(mm)

7 April 2005 Surface: WME (%) 18.5 In-depth 20(mm)

Position: Floor Type: Concrete Finish: Exposed

Reading(s): 25 January 2005 Surface: WME (%) 99 Surface

Kitchen 1 (total area: 20.00m²)

Ambient Reading(s): 25 January 2005 - 74 RH(%) - 11 Temp (°C)

Position: Floor Type: Concrete Finish: Exposed

Reading(s): 25 January 2005 Surface: WME (%) 99 Surface 7 April 2005 Surface: WME (%) 20 Surface 7 April 2005 Surface: WME (%) 20 Surface

Position: Wall Type: Brickwork-solid/with plaster Finish: Exposed Reading(s):

25 January 2005 Surface: WME (%) 99 Surface 9 March 2005 Indepth: WME (%) 19-30 In-depth 10(mm) 7 April 2005 Surface: WME (%) 16.5 In-depth 10(mm) 7 April 2005 Surface: WME (%) 16.5 In-depth 10(mm)

Lounge 1 (total area: 32.00m²)

Ambient Reading(s): 25 January 2005 - 74 RH(%) - 11 Temp (°C)

Position: Wall Type: Brickwork-solid/with plaster Finish: Exposed Reading(s):

25 January 2005 Surface: WME (%) 99 Surface 9 March 2005 Indepth: WME (%) 19-30 In-depth 10(mm) 7 April 2005 Surface: WME (%) 14 In-depth 10(mm) 7 April 2005 Surface: WME (%) 14 In-depth 10(mm)

Position: Floor Type: Concrete Finish: Exposed Reading(s): 25 January 2005 Surface: WME (%) 99 Surface 7 April 2005 Surface: WME (%) 20 Surface

7 April 2005 Surface: WME (%) 20 Surface

Currently Installed Equipment

Inventory No	Description	Date Installed	Days On Site
(None)			
Equipment	Removed		

Survery Summary for 16075: 17 Morton Street, , CARLISLE, , CA2 5UU

Page 3 of 4

Inv.No 4128	Descriptio MCS300 D	n Installed ehum093ifMear 2005	Removed 07 Apr 2005	Hours Onsite 691.82	Total consumption (kw) 1522.00
99999	MCS300 D	ehum2d5filtern 2005	07 Apr 2005	1720.31	3784.68
Possib	le Additio	onal Equipment R	equired		
Date Ci 25 Janu	reated lary 2005	Created By dbrogan	Description turbo fan	Requi 4	rement Estimate(Weeks)
Dispos	al(s) per '	Visit			
Appoin	tment	Total No. Of Bag(s)	Total No. Of Van(s)	Total No. Of	Skip(s)

Important Notes

Guide to readings taken using Protimeter moisture meters

Of all the materials found in buildings, wood is one for which a percent moisture content is meaningful; for it is generally accepted that wood rots when it is wetter than 20% and is safe below this level. This is why protimeter moisture meters have a scale for wood. In any material other than wood the meter will give readings of %Wood Moisture-Equivalent (%WME). Or putting in another way: %WME is the moisture level in any building material other than wood expressed as a moisture content of wood. Therefore a reading above 20% in any building material indicates a hazardous condition which must be investigated further.

Readings Key

% W.M.E. = Percentage Wood Moisture-Equivalent Less than 17% Greater than 17% but less than 20% Greater than 20%

- Material DRY - Material AT RISK - Material WET

%RH = Percentage Relative Humidity

Calibrated moisture measuring instruments are used to take readings to assess whether walls, floors and ceilings are wet, and require drying. These readings are only used as a guide when determining when a building is sufficiently dry and for it to be safely ready for refurbishment and redecoration work to commence. Ultimately Munters technicians' will use their experience and published standards and guidelines to determine when a buildin is sufficiently dry.