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#### FAILURES IN TRADITIONALLY CONSTRUCTED DOMESTIC CHIMNEYS

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#### ABSTRACT

The following paper sets out the conclusions reached by the Northern Ireland Housing Executive for the large scale failure of traditionally constructed domestic chimneys in their housing stock, with an account of the unsuccessful and successful remedial action which has been taken.

It also details the type of chimneys now used in newbuild in an attempt to overcome the problems of the past.

### INTRODUCTION

The N.I. Housing Executive owns approximately 180,000 dwellings of which 138,000 are heated by solid fuel appliances. Over the previous three years 21,500 chimneys were tested as a result of complaints or suspected defects. 80% of these failed the test and required extensive remedial treatment. Not all of the chimney failures were in old houses where one would expect some flue deterioration through age. Quite a large number were in relatively new houses only seven or eight years old.

Before discussing the reasons for these failures it is important to note that up to the late 1960s all the traditionally built chimneys were constructed specifically for open fires which had either (a) no back boiler or (b) a small back boiler for heating domestic hot water only. Whether these chimneys had a parged brick shaft or sewer pipes for liners or fireclay liners, they were in most instances, and still are, perfectly adequate for the type of open fire just described.

#### REASONS FOR FAILURES

Although all of the older types of chimneys were subject to the failures, it is considered sufficient to discuss the failures in the context of the chimney detailing which was common practice from the early 1960s as illustrated in Figure 1. A 200mm internal diameter fireclay flue liner which had a 240mm external diameter was built into a block shaft with 240 x 240mm internal dimensions; it was a tight fit.

With the advent of clean air zones in the late 1960s smokeless fuel appliances were installed into existing chimneys and also new chimneys which were built to the detail just described. These appliances were solid fuel glass fronted space heaters which usually contained a convection chamber, generally known in the UK as roomheaters and used for partial central heating as well as heating the domestic hot water.

The temperatures created by the roomheaters were far in excess of those which the flues could withstand. The flues were not insulated and there was no room for expansion. When the appliance was not in use the shaft cooled down very quickly. The intense heating and cooling caused the fireclay liners to crack. Cold air leaking into the flue in various places caused the smokeless fuel gases to condense. The condensates forming on the surface of the flue decreased its effective diameter and the acids in the condensates attacked the walls of the flue. As tenants rarely if ever seemed to clean their chimneys, the result of all this was blocked flues and its blocked flues which cause fatalities.

The problem was further exacerbated in the 1970s when the Housing Executive's heating policy was changed to one for full central heating. The high output appliances required to heat nine radiators plus the domestic hot water was even more detrimental to the uninsulated flues.

The fact that workmanship on the building sites seemed to be deteriorating all the time did not help matters. The joints of the fireclay liners were not lined up properly. The liners were often cut so advantage was not taken of the rebated or socketed joints. There were voids everywhere but particularly around offsets and anything that happened to be lying around the building site seemed to be used as fill between the liners and the blockwork shaft. Chimney construction is extremely difficult to supervise properly and even when it seemed correct, very often the perpendicular joints in the brickwork were not filled with mortar so air leaks were built in from the beginning.

With hindsight it became obvious that (a) the traditional flue detail for open fires was not adequate for roomheaters, (b) a system was required for ensuring that contractors give a great deal of care and attention to building chimneys and (c) tenants had to be actively encouraged to have their chimneys cleaned on a regular basis.

#### REMEDIAL ACTION

## Unsuccessful Remedial Action

Very often before roomheaters were installed, existing chimneys were relined using the poured flue system. This involved the use of a rubber former which was passed down the chimney and inflated. Then a feeder tube, which was inserted between the inflated former and chimney shaft, was used to pour in a prescribed mix of Ordinary Portland Cement and



Perlite (insulating material). After the insulating concrete was given time to set, the rubber former was deflated and removed leaving a relined chimney.

This method of relining was particularly popular because it was least disruptive to tenants. However, in 1985 the Housing Executive discontinued its use because of the following reasons:-

- (a) It was difficult if not impossible to clean a chimney thoroughly enough to obtain adhesion of the poured mix to the existing shaft.
- (b) It was difficult to centre the rubber former in the first instance and the insertion of the feeder hose caused further displacement which resulted in inconsistent thicknesses of the lining material throughout the height of the chimney.
- (c) The quality control of the insulating concrete mix is entirely in the hands of the site operatives and the mix is critical.
- (d) There was some evidence of segregation of the mix after installation.

The poured flue linings which were installed in 3,000 or more houses have since broken down in such large numbers that the Housing Executive have established a programme for their complete removal.

## Successful Remedial Action

Since 1985 all chimney relining has involved opening up chimneys and physically installing new liners. Only specialist contractors, technically approved by the Housing Executive are permitted to carry out this work.

Earlier this year the Executive's Research and Development Department completed a code of practice [1] for site supervisory officers and specialist contractors with the relevant information required to ensure that correct specifications are used for chimney relining work and that the quality of workmanship is consistent.

The code of practice covers in detail the following aspects of the work:-

- (1) Preliminary work required to the chimney which includes protection of heating appliance/fireplace, opening up positions, removal of chimney stack when required, examination/making good existing shaft and examination/possible replacement of concrete components.
- (2) Approved liners to be inserted which covers fireclay, refractory concrete and pumice; the diameters of liners required in various circumstances are also given.
- (3) Approved types of lightweight insulating void fill which is required between the liners and chimney shaft.
- (4) The relining process which sets out the sequence of construction from the heating appliance to the chimney pot and also specifies all the incidental materials required on the way such as mortar mixes, damp proof courses and flashings.

(5) Type and number of tests required subsequent to completion of relining work.

All of the Executive's approved chimney relining contractors were instructed to adhere to this code of practice and the renewal of their approval certificates was based on their written agreement to do so.

Isokaern Keddy, the Danish manufacturers of one of the Icelandic pumice liners have pioneered a reaming tool which may be used to take out certain types of existing broken down liners without opening up the chimney. New liners may also be inserted without opening up except at positions where the flue bends to change direction. The Housing Executive has used this system very successfully when relining chimneys which had poured or fireclay liners. This method is the least disruptive to tenants.

#### CURRENT NEWBUILD DETAILING

## Traditional Construction

The Housing Executive changed their traditional chimney detailing in the early 1980s to make it satisfactory for both roomheaters and open fires with high output back boilers. Since that time several revisions have been made as a result of site experience and performance in use. The current detailing is illustrated in Figure 2. It may be useful to draw particular attention to the following points:

- The recess of the heating appliance is rendered as it is often built shoddily and can leak. The openings for circulatory pipes are well sealed.
- Although it is Executive practice to have cavities in party walls, the wall is now always solid behind the heating chamber and the chimney shaft except in gable wall situations.
- 3. The chimney breast up to ground floor ceiling level is built in clay brickwork which withstands more heat than concrete blockwork and is less likely to crack.
- 4. In line with the recommendations in BS 6461 : Part 1 : 1984 [2] straight flues are used whenever possible. When the plan arrangement inside a house so dictates, an offset is introduced; an angle of  $37\frac{1}{2}^{\circ}$  from the vertical has been found to be the optimum in respect of brickwork detailing, level of frictional resistance to flow of fuel gases and ease of cleaning. It should be noted that in a very high percentage of the flue failures, the initial breakdown has been at the offset.
- 5. The minimum internal dimensions of any flue shaft is now 1<sup>1</sup>/<sub>2</sub> bricks x 1<sup>1</sup>/<sub>2</sub> bricks. As 200mm internal diameter flue liners are used, this gives a minimum thickness of 50mm of insulation between the external surface of the liner and flue shaft.
- All rebated or butt jointed liners, regardless of material type, require a galvanised steel locating collar at each joint.



- 7. Brickwork corbelling detailing in the roofspace must comform to good building practice and the external surface of the chimney shaft in the roofspace must be rendered. The second largest percentage of failures have occured because of breakdown of flues in this area.
- 8. It is essential that damp proof courses and lead flashings to the chimney stack are effective. If the insulating material around the flue liners becomes damp, the chilling effect causes large quantities of condensates to form inside the flue in a very short time.
- Before fitting the coping and chimney pot, 75mm of waterproof mortar must be used to seal the top of the insulating void fill.
- 10. The Housing Executive only use approved concrete components, purpose made to their requirements, e.g. lintels over roomheaters, throating blocks for open fires and chimney copings. In respect of the earlier points about preventing rainwater from penetrating the insulation material, it is important that concrete copings have rebated circular openings to receive chimney pots which are then pointed and flaunched in waterproof mortar with a bonding agent.

All newbuild chimneys receive core ball and smoke tests twice before practical completion and once at the end of the defects liability period.

## Precast Lightweight Concrete Flue Systems

For several years the Housing Executive have been using precast lightweight concrete flue systems in existing houses where district, electric or gas heating has been replaced by solid fuel heating. More recently these have also been used in a percentage of newbuild.

The idea originated in Denmark although several British manufacturers now also produce these interlocking block chimneys. The Housing Executive prefer the systems which have a two part block e.g. an outer casing and separate liner. The material/s used for the blocks vary depending on the manufacturer and country of origin. Some are made entirely of pumice concrete while others have refractory concrete or GRC outer casings with ceramic liners.

The advantages of these systems are that many inherent problems in chimney construction have been designed out and erection is a quick, relatively easy process. However, because its a deceptively simple operation, mistakes can happen and problems do arise although its unlikely these would have such a detrimental effect as those experienced with traditional construction.

## REFERENCES

- Research & Development (Architecture), NI Housing Executive Code of Practice, Installation of Chimney Flue Linings to Existing Chimneys, Ref: AGRY, January 1988.
- BS 6461:Part 1:1984, British Standard, Installations of Chimneys and Flues for Domestic Appliances Burning Solid Fuel (including wood and peat), Part 1 Code of Practice for Masonry Chimneys and Flue Pipes, p3, para 4.5.