THE DEVELOPMENT AND IMPLEMENTATION OF RADON PROTECTIVE MEASURES IN UK DWELLINGS

by: Chris Scivyer, Michael Woolliscroft and Lynn Parkins
Building Research Establishment
Bucknells Lane, Watford, WD2 7JR
United Kingdom
Tel: (44) 923 894040

ABSTRACT

Interim guidance developed by The Building Research Establishment (BRE) on protection of new dwellings against radon was implemented, under Part C of the Building Regulations for England and Wales July 1988. It only affected new dwellings constructed in the counties of Cornwall and Devon, where the UK's highest incidence of radon is found. In order to ascertain the effectiveness of this guidance BRE undertook a series of field trials monitoring progress on more than 40 sites. Observational studies were carried out to identify any buildability problems. Radon measurements were carried out in over 450 newly occupied houses. Where possible both protected and unprotected dwellings alongside each other were monitored. Extensive consultation took place with representatives of the UK construction industry. The findings of this research were incorporated into the 1992 revision of Part C of the Building Regulations for England and Wales. The guidance has since been further revised to include the counties of Northamptonshire, Derbyshire, and Somerset. This paper describes how the field trials were conducted and discusses the results and progress to date.

INTRODUCTION

As a result of growing concern about the problem of radon particularly in the south west of England (eg. Wrixon et al. 1988), Interim guidance on the protection of new dwellings against Radon was implemented under Part C of the UK Building Regulations in June 1988 (eg. Building Regulations, Interim Guidance, 1988). This guidance had been developed over a two year period by The Building Research Establishment (BRE) in conjunction with a small number of builders and developers in the south west of England.

To check the effectiveness of the interim guidance a series of field trials were carried out on a number of sites within the affected area. Practical building aspects of the guidance were examined, as well as monitoring radon levels within completed dwellings. The results of these field trials led to improved guidance (eg. BRE Report BR211,1991) and to the inclusion of radon protection in revised Approved Documents supporting Building Regulations in 1992. The guidance has since been implemented in a further three counties in England.

Further site observational studies and radon measurement are in progress in these new areas. The aim of these studies is to fill gaps in existing knowledge, assess regional differences and monitor further new products and techniques.

This paper describes how the field trials were conducted and discusses the results and progress to date.

DEVELOPMENT OF INTERIM GUIDANCE

In 1986 the Department of Environment (DOE), Building Regulations Division, commissioned BRE to develop radon protective measures for new dwellings, in conjunction with the UK construction industry. Following preliminary discussions, various protective and precautionary measures were installed by a few contractors in the south west of England. Primarily, protective measures comprised passive radon barriers, and precautionary measures involved providing radon sumps which could be activated at a later date. The aim was to develop measures which would be capable of being incorporated into standard UK house construction. Also where possible solutions should be passive not active. The use of fans for example should only be considered for remediation.

Interim guidance was introduced in 1988 for those parts of the country most at risk. As a consequence the guidance only applied to the counties of Devon and Cornwall. Available geological and radiological data was then used to divide the two counties into areas of risk. In areas where more than ten percent of existing houses were expected to exceed the UK Radon Action Level both protective and precautionary measures were advised. In the remaining areas only precautionary measures were recommended.

In cases where only precautionary measures were required, the provision of a ventilated subfloor void or radon sump was recommended. In either case an electric fan could easily be coupled to provide depressurisation of the subfloor space, should it prove necessary at a later date. Where protective measures were required a radon barrier had to be incorporated across the complete ground floor area. This barrier had to extend far enough to seal the wall cavity. The radon barrier could be incorporated into either in-situ or suspended concrete floor construction. In addition to providing the protection it was considered prudent to require the precautionary measures as well. The use of suspended timber floors was generally discouraged; although they could be used, provided they were located above a fully protected concrete slab. Limited guidance was given on the need to seal around service entries and exits, and the possible problems likely where stepped foundations or retaining walls were used.

FIELD TRIALS

An initial field survey of the effectiveness of these measures was carried out in 1989/90 (eg. Wozniak and Scivyer 1990) on 136 houses. It was extended in 1990/91 to include a total of 423 houses, and included houses both with and without protection measures.(eg. Woolliscroft, et al 1993).

Monitoring was undertaken in two stages. During the construction phase site observational studies were carried out. This included inspection of drawings, materials, construction methods and workmanship, the main aim being to see how practical the solutions were proving in the harsh environment of the building site. On completion each house, once occupied, was measured over the winter for a three month period using etch-track detectors.

RADON MEASUREMENTS

To test statistically for the effect of a number of factors which might affect the dependent variable, the annual average indoor radon level, ideally we would have chosen a balanced block design with equal numbers in each block and the sites would have been chosen randomly within the high and low radon areas. In reality however we had to make do with real building sites. The actual number of houses and sites monitored was to a large extent dictated by the willingness of builders and householders to co-operate with the survey. Another influence which reduced the overall number of houses available was the recession in new house building. Even so a variety of different sites, construction types, and size and type of dwelling were included in the sample.

There are three main factors considered likely to affect the annual average indoor radon level :

1. The Radon level of the area.

2. The type of construction.

3. The presence or otherwise of a membrane.

The Radon Level Of The Area - 1

This is based on the results of monitoring radon levels in existing houses. This has been characterised (eg. Scott 1992) as the most cost effective predictor of radon concentrations in future houses, and has been used by the UK government to determine affected areas. For our field trials houses could be divided into :-

(i) high radon areas:

those areas, where in houses with no protection and conventional construction, one could expect 30 percent of the houses to be over the action level and

(ii) medium radon areas:

those areas where between 10 percent and 30 percent of houses would be expected to be over the action level, with conventional construction without protection.

Out of 416 dwellings in the main analysis, 295 were in the medium radon and 121 in the high radon areas. It was inevitable that we would sample more dwellings in the medium radon areas, because more dwellings come into the medium than the high radon areas. In addition in many of the higher radon risk areas such as Dartmoor little new construction is likely due to planning constraints. Nevertheless we did achieve a reasonable size sample in the high radon areas.

Type Of Construction - 2

The survey included 33 sites spread right across Devon and Cornwall. They included the full range of dwelling types from small terraced houses to substantial detached houses and bungalows. Sites ranged from small sites with only a handful of houses to large sites with several hundred houses being built by more than one national builder. Both flat and hilly sites were included.

Predominantly the houses were of brick and block cavity construction although there were a few timber framed houses. Floor construction was primarily one of two types, either cast in-situ concrete or suspended beam and block. There were also just a few with concrete raft foundations (too few to include in the main analysis). It should be noted that the use of beam and block floors has only recently been introduced into the south west of England. It is likely that if the survey were carried out today a far higher percentage of houses would have beam and block floors. The protected houses incorporated a radon barrier within the floor construction. Most had taped polyethylene radon barriers, although proprietary welded seam or bituminous coated polyethylene products were used on some sites.

As the houses had been built over a two to three year period, the later houses tended to incorporate more robust solutions. One example of this was the way in which service entries and exits were dealt with. On earlier houses pipes were often simply sealed to the main radon-proof barrier using tape, whereas on later houses specially developed prefabricated seals were beginning to be used.

The Presence Or Otherwise Of A Membrane - 3

The main difference between the protected and unprotected houses was the inclusion of a radon barrier in the protected houses. UK houses normally have a polyethylene sheet membrane within the floor to provide protection against moisture. In a radon protected house this barrier is extended to the outside of the external wall, to seal both the cavity and the floor to wall joint. It is acknowledged that some diffusion will occur through the sheet. However, as most radon entry is through cracks, this diffusion can be ignored. Of particular interest were the houses where, due to the terrain, part of the house was either stepped or dug in to the side of a hill. In such cases the radon barrier had to be incorporated into the retaining walls as well as the floor.

SITE OBSERVATIONAL STUDY

Due to constraints in both time and builder/householder co-operation, measurement was only possible in just over 400 houses on 33 sites. However, observational studies of building practice were able to be carried out on about twice as many sites with three times as many houses. The aim of these studies was to identify any practical difficulties being encountered by operatives and supervisors during construction. It is very easy for a designer to specify that a barrier should be incorporated within the floor construction. However, specification drawings rarely show how awkward details, such as corners and steps in barriers, can be constructed. Much of this has to be figured out by the site operatives themselves.

Similarly, many materials and techniques are susceptible to damage unless work on site is carefully co-ordinated and weather conditions suitable. For example, trying to join two polyethylene sheets with adhesive tape on a wet and windy site is unlikely to result in a gastight barrier. As a consequence methods have been developed to minimise exposure of barriers to damage by weather or site traffic.

RESULTS

The full results of the field trials have been reported elsewhere (Woolliscroft et al 1993). Briefly however, from the analysis carried out there is evidence that the radon protection measures now recommended in the Approved Document to Part C of the UK Building Regulations and the BRE Report BR211 Radon Protective Measures for new dwellings, actually work in practice. They reduce significantly both the proportion of houses above the action level, and the average indoor radon level.

	PROTECTED	UNPROTECTED
BLOCK AND BEAM	1	21
IN-SITU CONCRETE	7	25

Table 1. percentage of dwellings above action level as a percentage of all dwellings in each category

The results suggest about a 50 percent reduction,(or a halving) of the radon level by either natural ventilation to the subfloor void (at levels required by building regulations) or by the provision of a membrane.

	PROTECTED	UNPROTECTED
BLOCK AND BEAM	47	103
IN-SITU CONCRETE	87	194

Table 2. Mean Annual Average Indoor radon Levels Bq/m3 with different type of construction and with or without membranes

From observations on site it was apparent that the interim guidance issued in 1988 was working well. Even so there were one or two areas where further advice was needed. As a consequence the BRE Report on radon protective measures for new dwellings included additional guidance on the design of barriers and sump systems.

As with anything new, there was at first a certain amount of apathy amongst site operatives towards the installation of radon barriers. However, once they were made aware of why radon protection measures were needed a reasonably high standard of workmanship resulted. Likewise methods of working were developed to minimise damage to the barrier during construction. Manufacturers have also responded to the need for robust solutions, and have developed a number of products for use in radon areas. These include prefabricated sumps, methods for sealing membranes, and cavity trays for sealing across cavity walls.

CONCLUSIONS

The field studies indicate there is strong evidence that the provision of a radon proof membrane in accordance with the 1988 interim guidance (which in principle is not different from current guidance) reduces the annual average indoor radon levels significantly and on average this reduction is about a half; and it also reduces the number of houses above the action level.

There is less strong evidence to show that block and beam floor construction is better than insitu concrete in reducing radon levels. However it does appear that block and beam construction (incorporating underfloor ventilation as required by current UK building regulations) reduces annual average indoor radon level by half.

Although it cannot be said that having applied the recommendations of the Approved Document an individual house has been radon proofed. It is true to say that as a result the probability of that house having a radon level above the action level will have been substantially reduced.

REFERENCES

BUILDING REGULATIONS DIVISION, DEPT OF THE ENVIRONMENT, Interim Guidance on protective measures for new dwellings. London DOE June 1988.

BUILDING RESEARCH ESTABLISHMENT, Radon : Guidance on protective measures for new dwellings. BRE Report BR211. 1991.

SCOTT.A.G. Site Characteristics for radon supply potential: A progress review. Health Physics 1992.

WOOLLISCROFT M, SCIVYER C and PARKINS L. Field trials on the effectiveness of radon protection measures in new dwellings. Paper presented at the first International Radon Conference, Rimini, Italy, June 1993.

WOZNIAK SJ and SCIVYER C. Report on the BRE radon field trials in new houses 1989-90 BRE Client Report November 1990.

WRIXON A. et al. Natural Radiation Exposure in UK Dwellings. National Radiological Protection Board, Chilton,Didcot, Oxon May 1988