# Women engineers in UK construction research establishments in the mid-20th century. A preliminary survey.

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## Introduction

From the advent of the Industrial Revolution in the late 19th century to the start of the First World War in 1914 engineering had made astonishing advances. Steam-driven equipment of many sorts was ubiquitous, the automobile becoming more widely seen and aeroplanes just taking to the skies. However, the UK construction industry had, to a great extent, been left behind in comparison and was mostly still relying on the crafts of many centuries, even when asked to use innovations such as reinforced concrete. What relevant research had been done, into the theories of structures and thermodynamics for instance, in the great universities, did not generally reach the ordinary building contractors, and there were no published standards or specifications. Some of these problems emerged during the war itself and in 1915 the UK government set up a committee to provide for scientific and industrial research. At the end of the war there was a desire to demolish old slums and provide 'homes fit for heroes', at a time when both materials and skilled men had been swallowed up by the war, although many entrepreneurs did try to promote untested innovations. In 1920 the Building Research Board (BRB) was set up and H.O. Weller appointed to run it, establishing its first facility, at East Acton, near London in 1921 [1]. Through a variety of names, structures, locations and funding models this research service for the building world continues to this day [2].

Construction history remains loosely defined but is generally taken to cover the people, methods, materials and systems which have allowed buildings and other structures to be built. Addis' analysis of papers in the Journal of Construction History found that about 9% of articles were biographical and a total of 11% related to the histories of organisations, trades and professions. [3] For most of the period since 1800 (78% of articles) it was difficult or, at best, unusual for women to have access to the sort of training that would enable them to take significant roles in construction and many of the biographical papers relate to the well-known men of various eras. However, it is millennia since construction of most sorts was the outcome of a single individual's work and the emerging stories of the essential work of people other than "The great man" are starting to attract more interest in all historical fields, e.g. the "Hidden Figures" women at NASA [4].

Although many women had worked successfully at all levels of engineering work during the First World War and some were starting to get relevant university degrees [5] the post-war period was overtly hostile to them remaining in or entering engineering at the professional level [6]. However, the inter-war era saw many women enter the defence-related scientific civil service and have successful careers and the 1940s seems to have been when this also happened in the construction-related government research organisations.

## Government And Industry Research Organisations

The first half of the 20$^{th}$ century saw many government research establishments and committees established for numerous industrial sectors. Where the government did not provide one, many industries set up their own co-operative research associations under a 1916 scheme which gave them some state support until about 1932. Many continued in various forms and from time to time the government was able to provide some financial aid. In 1965 there were some 48 such

associations [7] but most had no direct connection with construction, apart from the Research Association of British Paint, Colour and Varnish Manufacturers, the Timber Research and Development Association and the Heating and Ventilating Research Association. Presumably the remaining specialisms in construction found their needs adequately served by the government's Building (BRS), Fire (FRS), Forest Products (FPRS) and Fuel Research Stations (FuRS) and the Transport and Road Research Laboratory (TRRL).

The Fuel Research Station (Monkhouse 1959) was the first to be set up, at East Greenwich in 1919, and was to work on the usage and uses of various fuels, including the development of smokeless fuels and the production of oil from coal. As coal was the principal fuel until after the Second World War, there were soon a plethora of other coal-related laboratories, both government and industry-funded.

The BRS (later Building Research Establishment BRE) was asked to do general research into the physical and chemical sciences of buildings, their materials, structures and behaviour.

The BRS was also expected to undertake contract research for companies and to answer quicker questions from its developing body of knowledge. It was funded by a varying mixture of state and commercial funding, until full privatisation in the late 20th century.

## Women in the Civil Service

Some of the very first women to be regularly employed in public service in the UK were Post Office telegraphists in the 1860s, but it would be a long time before women were able to join the civil service establishment (permanent staff cohort) on an equal basis with men (1929) and yet longer before they were on equal pay and grading systems (1970s). For most of that period women were either required by law, or expected by social convention, to 'retire' on marriage or at least on the birth of a first child. Exemptions from the so-called 'marriage bar' were possible for women of exceptional calibre, where the (male) director of their service was willing to make a case for them to remain. In the period 1930-38, eight such outstanding women were able to remain after marriage [9]. Such male 'allies' would have made a big difference for women entering and progressing in the male-majority technical grades.

Entry by some women into scientific research within the UK civil service was possible and several who entered in the 1920s and 1930s had full careers in, for example, the Royal Aircraft Establishment [10]. It may have been that the structured environment of government service, following the 1929 Tomlin Commission, [11] was a slightly more welcoming one than industry, although few such women rose to the senior grades of the scientific civil service. It would however take until the Second World War before women joined the Building Research Station.

Sources for identifying women who worked at, or were on advisory committees for, the BRS and its sister organisations have been limited to those available directly online or loaned items from helpful colleagues, since most of this research was done after the advent of Covid19 and resultant closures of physical archives. Since the majority of the women do not even have Wikipedia pages, let alone entries in the Oxford Dictionary of National Biography, much of the research has had to be from scratch. Starting points included BRB annual reports to find names, which were then followed through using biographical, genealogical and bibliographical sources.

## Fire Safety

It is not surprising that the bombing raids of the Second World War focused minds on the fire safety of various sorts of buildings and the fire resistance of materials. Some of the most influential research into the behaviour of fire and smoke in buildings was by Margaret Law MBE BSc CEng FIFireE FSFPE (1928-2017), who was considered by her contemporaries to be a pioneer in the, then new, field of fire engineering [12]. Law's first job after university was at the

government's Fire Research Station in Borehamwood, in 1952 - only 3 years after it was established. Her experimental work featured on the FRS's research report cover in 1952 (Fig.1) [13]. During her 20 year association with the FRS (which later became part of the Building Research Establishment) she contributed to 34 Fire Research Notes [14]. The topics ranged from the small, domestic issues of cooker fires in caravans and prefabs, to the cold war concerns of the potential for nuclear radiation to start fires: "On The Possibility of Ignition of Materials by Radiation from Nuclear Explosions". Her interests were in the effects of materials and structures on fires and how they spread, such as how fire moves through high rise flats with balconies, or the optimum protective coating for structural steelwork. The recent Grenfell Tower fire disaster not long after her death shows how that aspect of Law's work remains relevant [15].

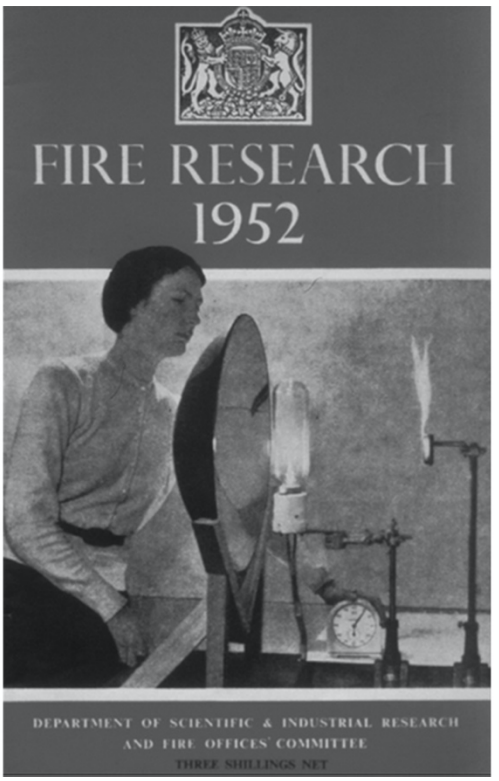


*Figure 1. Fire Research Station 1952 Report [14]*

In 1974 Law moved to the Ove Arup Partnership to work on the fire engineering for their major projects, and was part of the specialist team that investigated the Bradford City Stadium fire which killed 56 people in 1985, which led to the end of wooden grandstands. Her extensive theoretical and practical research [16] led to changes in Building Regulations, Codes of Practice, and design guides, such that she became one of the world's leading fire scientists.

Law's near-contemporary, Monica M. Raftery BSc (1929-2009) worked first at the British Coal Utilisation Research Association and then spent the rest of her career at the FRS, working on explosivity of industrial dusts and the behaviour of fire in domestic settings. Her work considered the safety or otherwise of modern bedding and soft furnishings [17] as well as the general behaviour of fires in ventilated rooms. As timber framed housing became more prevalent, in 1987 the FRS was asked to investigate if a serious fire could result from membrane ignition particularly where cavity barriers were ineffective of absent. Of the three membranes approved for use at that time, Raftery's work [18] showed that thermoplastic film membranes would be the least likely to support a fire.

Concerns about fire fatalities in homes in multiple occupation (HMOs) led the Ministry of Housing and Local Government to commission the Fire Research Station in Borehamwood to look into the fire risks in particular. Winifred Nora Daxon (nee Hammond) (1922-2007) undertook the research on this, publishing her results in 1971. She found that portable oil-fuelled heaters (paraffin) were the main cause of fires in HMOs and that:

> "The occupant of a multi-occupancy dwelling is more likely to die in a fire than in a single occupancy, is about 4 times as likely to become a non-fatal casualty and is about 14 times as likely to be placed in a dangerous situation [19]."

HMOs continue to be higher risk from fire than single occupancies and, although paraffin heaters are largely a thing of the past, the risks they (and portable gas heaters) pose continue to be highlighted in HMO regulation and advice [20].

## Building Materials

The development and testing of novel building materials was a large part of the work of the BRS between the wars. Reinforcement in concrete was still considered a new technique and many ideas came onto the market to replace traditional masonry work with simulated 'stone' blocks. The masonry industry had been significantly hit by the loss of time-served masons due to the war and that there were not many young men were entering apprenticeships due to the very demanding nature of the work and its associated health risks (silicosis of the lungs). Since the major component of the costs of including traditional stonework in new buildings was the wages for the skilled masons, many building materials suppliers decided that there would be a market for a reconstituted or artificial stone, which could be made in any shape or size required by the client. Mrs. Anne Greaves, a successful Yorkshirewoman who ran her own Weeland Quarries company, devised her own 'Betna cast stone' which she believed would resist attack by acid rain better than real stone.


*Figure 2. Betna Advertisement [23]*

In her 1929 article for The Woman Engineer she commented that

> "Mr. Brady and his assistants at the Government Research Station at Watford have been making very extensive tests on this point… …. The Director told me they had been doing a very great deal of experimental work on reconstructed stone..." [21]

Greaves was also very well informed on the science of cements, fully appreciating the benefits of not using too much water in a mix, probably because she was an active (and first female) member of the Institute of Quarrying. Her Betna stone was used in several major contracts, for a hospital and some housing.

A generation later, innovative reinforcing materials were being sought for concretes and Valerie Laws, BSc, MSc, having started out doing strength and structures of nylon and wool fibres for fabrics, for Australia's Commonwealth Scientific and Industrial Research Organization, moved to the UK in the early 1960s to work on the properties of coconut fibres, for the Tropical Products Research Institute. She became a Senior Scientific Officer at the BRS, sometimes also at the National Physical laboratory, working on the use of various fibres for reinforcing concretes [22].

## Method study

Given the low level of basic scientific understanding of materials and techniques, it is perhaps not surprising that the first 20 years of the BRS were fully engaged looking into those and the need to address efficiency and optimisation was not considered until the war years, when new bricklaying methods and the labour times for housebuilding were examined for the first time. In 1946 a Method Study department was set up, to look at "industrial psychology and physiology, the efficiency of mechanical equipment in terms of economy in labour, and the comparison in labour yield of different forms of construction [23]."

Lemessany and Clapp were the duo that led in this field. Margaret Alison Clapp BSc (1925-1994) was at the BRS from 1959 (maybe earlier) as a Senior Scientific Officer, initially publishing reports on costs and productivity on building sites, as sole or lead author, from 1963-73 [24]. Her work must have involved extended visits to the then exclusively-male environment of building sites, her achievements are all the more remarkable considering she was described by a colleague as "… very quiet and unassuming lady, diligent and effective but not particularly out-going [25]." From the early 1970s Clapp worked with Lemessany. Dr Julia Lemessany (c.1928-? Lemeššanyiova) was originally from the former Czechoslovakia. Although nothing is known of her earlier life, it is thought she came to the UK after the Soviet invasion in the late 1960s, and was naturalised as a UK citizen in 1974 [26]. In contrast to Clapp, Lemessany was recalled as a forceful, determined character and from 1973-87 she was lead author on papers with E.E. Amos and later with Clapp, all on building economics, and labour/materials requirements for local authority construction. Lemessany and Clapp's works continue to be widely cited but many in the industry today do not realise they were both women.

## Heating and ventilation

When the Building Research Board started work, by far the majority of British homes were heated by coal, many areas did not have electricity at all and even gas supplies were not ubiquitous, there not being national grids for either gas or electricity at that time [27].

The only woman to be mentioned in Lea's history of the Building Research Station [28], despite never working there and despite some women in her field who were working there at the time but not mentioned, Dr Margaret Fishenden DSc, FIoP (nee White) (1889-1977), was an academic and industrial researcher renowned for her work on air pollution and domestic heating in an almost entirely coal-fired era.

She joined the Manchester corporation air pollution advisory board in 1916, and began her work on the efficiency or otherwise of coal fires and domestic grates, publishing several books and important reports for the Fuel Research Board. Having gained a DSc in 1919, in 1922 she moved to the Department of Scientific and Industrial Research, joining Dr C. H. Lander and O. A. Saunders, who would be her co-authors for many years. The trio moved to the Department of Engineering, Mechanical and Motive Power at Imperial College in 1932, where she rose to senior lecturer and, in 1947, assistant professor and reader in applied heat, a remarkable achievement for a woman at that time. Her work at Imperial College was largely on heat transfer, on which topic she authored many papers and reports, including for the shipbuilding industry. Her work with the BRB was as an advisor on its heating and ventilation advisory committee, from (or before) 1934 until her retirement in 1957 [29]. This committee (chaired by Sir Alfred Egerton) ensured research was done to ascertain such basics as what standards for home insulation or home heating levels should be set [30]. The standard for home heating was set very low: the background temperature throughout a home should be maintained at 10$^{o}$C with additional heating in occupied rooms such as living rooms. More or less no homes were being built with insulation, except the incidental effect of any wall cavities.

Work to clarify what was needed to ensure homes were comfortably warm at an affordable price was undertaken by the duo of Black & Milroy, who published extensively on heating and ventilation for high density social housing and for office blocks. Flora Black BSc (nee Weir, 1919-1998) gained a degree in Natural Philosophy from the University of Aberdeen in 1940, did 2 years research there and then joined the Ministry of Works to do housing design. In 1950 she moved to the Department of Science and Industry's Building Research Establishment at Garston and also published her first sole-author paper, based on her experimental work at the Ministry of Works Field Test Unit at the Thatched Barn Hotel, Barnet. She remained with the BRS, progressing from Senior Scientific Officer to Principal Scientific Officer and retired in 1978. Over the course of her productive and influential career she published numerous BRS Reports and Notes, as well as journal papers. The junior half of the partnership was Elisabeth Anne Milroy (1921-2006), who had a social work diploma and the Chartered Surveyor's Institute's Women Housing Manager's certificate, for which she was awarded the 1945 Octavia Hill Prize for getting the highest marks. Her first professional work was on requisitioning houses and arranging for new homes for bombed-out families. By 1952 she was working at the Building Research Establishment (BRE) and had co-authored her first paper, 'House Heating and the Tenant: Experiments at Abbots Langley'. She remained at the BRE until at least 1969, mostly working as Flora W. Black's assistant and occasional co-author, despite her lack of an engineering education.

## Building standards

The slum clearances and the urgency of the housing shortage, following the First World War, led to pioneering housing surveys, mainly in London boroughs but also in Birmingham, Manchester, and Edinburgh. These surveys were commissioned by public authorities and also by private charitable groups hoping to establish social housing associations in their areas. These surveys were done by Irene Turberville Barclay (nee Martin) OBE, FRICS (1894-1989) [31], the first woman to qualify as a chartered surveyor with the Surveyors' Institution (now the Royal Institution of Chartered Surveyors), followed by Evelyn Perry who then joined Barclay in partnership as surveyors and housing managers. Barclay's unique contribution was to involve the local residents in the surveys. She went on to campaign and find funding for (principally, but amongst others) St Pancras Housing Association, for which she also did some design work, as well as managing the properties on a contract basis. Her work significantly raised the standards of space, services (including bathrooms) and building design quality of the homes as well as the provision of gardens, play spaces and social provision for the estates. This at a time when (apocryphally perhaps) it was often openly said of poor people that "if you give these people baths, they will only keep coal in them", to which her riposte was "Why should anyone who has a coal bunker put coal in the bath [32]."

Although not qualified in engineering specifically, Barclay's expertise in heating and ventilation for mass housing was widely recognised and she was actively involved in the Building Research Board's Post-War Studies reconstruction

committee on Heating and Ventilation, where she was joined by one other woman, Helen Brown, an Oxford city councillor [33]. Barclay was also active with the Women's Advisory Council on Solid Fuel (unkindly nicknamed The Solid Women) [34]. The WACSF advised women on the selection, use and workings of solid fuel domestic appliances, and advised the industry and government on potential British Standards and design. In this, it did similar work to its better-known sister organisations – the Electrical Association for Women, and the Women's Gas Council.

Picking up from Barclay's pioneering work on housing standards was Evelyn Judith Cibula BSc (nee Elbogen, 1927-2013), who came to the UK as a pre-war Jewish refugee from Poland, and gained her degree from London University. Unusually for the era, Cibula continued her work with the BRS after her marriage, and published a dozen reports on international building standards between 1970-80. Winifred Vere Hole, MA, PhD (c.1913-1992), was of a generation of young adventurous Australians who travelled to the UK in search of opportunities not available at home. Arriving in the early 1950s she had a 30-year career as a social anthropologist at the BRS, gained a PhD from London University, on working class housing. Between 1965-83 she published some 15 reports and is particularly remembered for her work on how post-war social changes were changing the ways in which residents ('users') actually used the indoor and outdoor spaces in local authority housing estates. Her 1966 report on play facilities found that there was no substitute for small playgrounds on each estate and that inactive as well as active play had both to be catered for [35]. An explicitly feminist woman who had little patience with her home country's then misogynist culture, Hole was able to see past her own privilege to discern the needs and preferences of others [36].

## Discussion

This necessarily brief survey of some of the work of some of the women scientific civil servants at the BRS/BRE up to about the 1980s, demonstrates the wide range of scientific, technical and sociological contributions they made, especially in the period after the Second World War. It demonstrates that, even when their work is still recalled and cited, the fact that they were women has often been forgotten. Some might argue that this demonstrates that their work was the more important thing about them and that their sex or gender was and is not relevant to the history of the BRS. Whilst we know that some were explicitly feminist, during the 'Second Wave of Feminism', others were either pragmatic or were too immersed in their work to show any opinions on that issue. The construction and extraction industries remain amongst the least diverse in the UK, especially at site level, so one benefit of bringing the work of women to a wider audience is to demonstrate girls and young women that women have been doing important work in those industries for a long time.

The other reason this search for the work of women scientific civil servants is worthwhile, would be equally applicable to their male contemporaries: to remind us that our knowledge today is not just the world-changing discoveries of a handful of famous men much praised in their own lifetimes. It is also dependent upon the contributions of the men and women who never rose to such fame: brick by brick their discoveries set the foundations for each improvement we take for granted in the built environment today.

## Acknowledgements

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