CHAPTER I

INTRODUCTION

1.1 GENERAL

Indian economy is mainly dependent on the agricultural resources. Nearly 75 percent of the Indian population is from rural areas and all the metropolitan cities are surrounded by slums and squatter settlements. The problem of providing shelter to the vast Indian population has been haunting the policy makers, planners, architects, engineers, and builders ever since independence with no satisfactory solution in the fore sight. Although, no one can deny that there has been quantitative growth and qualitative improvement in the housing stock during the past, the gap between the demand and the availability of housing has been continuously widening. The total backlog of housing needs which was estimated in 1981 to be 16.3 million units in rural areas and 8.2 million units in urban areas, which has grown further during the recent years. The gravity of housing problem is further compounded by the phenomenal increase in prices of building materials over a short period of time. Thus, today we are caught in a quagmire wherein, on one hand the overall deficit in housing is to the tune of 25 million units, and on the other hand, exorbitant building cost have drastically curtailed the purchasing power of the public. It is estimated that only 40 percent of the total populace can afford

pucka houses, while the rest are destained to live in mud and thatched houses for at least another 30 to 40 years to come.

1.2 URBANISATION AND MASS HOUSING

Urbanisation has become the order of this day and after the liberalisation policy more attention has been diverted to the development of industrial cities. For a healthy growth of a city, housing and employment must go hand in hand. In order to meet this goal, mass housing schemes are implemented nearer to the industrial belts. This trend will obviously attract more people from rural and ultimately lead to the problem of pollution due to domestic and industrial wastes. To alleviate the pollution problem the wastes may be converted into useful building materials. Among the many industrial wastes, the potential materials viable to be used for construction purpose are listed in Table 1.1.

Industrial revolution, though a pre-requisite to prosperity, strictly demands sufficient supply of essential building materials continuously, in particular, cement and bricks. The world production of cement has crossed 1.2 billion tonnes per annum with China leading with an annual production of more than 300 million tonnes, followed by Japan, USA, and India. Between 1940 and 1990, the average per capita consumption of cement in the world has gone up from 50 kilo gramme to 220 kilo gramme. The Indian cement industry has already reached a production

level of 30 million tonnes during the first half of the year 1994. Even though the growth of Indian cement industry has been encouraging, the average per capita consumption of cement at present is low at 64 kilogram.

Among the various industrial wastes listed in Table1.1, Pulverised Fuel Ash (PFA) or called Fly(ing) Ash is showing a promising trend to fight against the growing demand of cement and building bricks. At present production level of fly ash is nearly 40 percent of the total quantity of wastes produced in India annually. Organised and scientific ways of fly ash utilisation might immensely help the construction industry.

1.3 PFA - A VIABLE ALTERNATIVE

Pulverised fuel ash is being spewed out by thermal power plants where finely pulverised coal is used as the fuel. In furnaces where the temperature is around 1500°C the carbonaceous content is burnt instantaneously and the remaining matters like shale and clay form into very fine spherical particles. Most of these particles are carried with the out going flue gas, which is passed through either mechanical dust collectors or electro - static precipitators before being let into the air. This ash of pulverised coal fuel is normally dumped in the vicinity of power plants has become an industrial hazard. In the bulk of PFA, nearly 20 percent of it being lighter than air which pollutes the air and causes serious problems and

respiratory troubles to those inhaling it. Quite often letting out into streams and rivers, it also disrupts aquatic life cycles. The large quantities dumped on land swallow large tracts of cultivable land, causing ecological and environmental problems. An example of the havoc caused by the breach of huge fly ash pond of Vijayawada Thermal Power Plant in November-11,1990 reminds us the responsibility of disposing PFA in useful and environment friendly manner [1]. Another recent example is that Ennore Thermal Power Station, Madras has been given a warning by Tamil Nadu pollution Control Board to carry out effective antipollution measures [2]. The authorities are very much concerned that due to lack of awareness of building industry, only 50 tonnes of PFA is utilised by the cement industries out of a total daily production of 2000 tonnes.

In 1977, Manz [3] reported the worldwide production of PFA to be about 280 million tonnes of which approximately 11.4 percent was used mainly in cement and concrete. In 1982, Idorn [4] reported that in the year 1978 France utilised as high as 24 percent of its PFA production anually and in the same year India utilised only 1 percent of its annual production. In 1994, Raju [5] reported that PFA production world wide was 300 million tonnes and its utilisation in France had shot upto 50 percent whereas Indian utilisation still remained at the same level of 1 percent. World wide annual production of PFA and its use in concrete is shown in Fig 1.1 as reported by Raju [5]. In India, at present about 65 thermal power plants

generate 40 million tonnes of PFA every year. This figure is likely to touch 70 million tonnes by 2000 A.D. The marginal utilisation of PFA in India could be due to the absence of organised building and construction industry, high initial investment in setting up PFA based building material units, general apathy of material manufacturers and builders and a lack of will on the part of the Government to promote PFA utilisation.

Autoclaved Cellular Concrete (ACC) or called autoclaved aerated concrete has gained popularity in Europe, USA., and U.K.. It is one among a handful of promising new building products that incorporates a relatively high volumes of PFA. ACC blocks could be easily cut by a handsaw and they become appropriate for high-rise buildings. In India, a few research organisations, such as, Central Fuel Research Institute (CFRI), Central Power Research Institute(CPRI), National Thermal Power Corporation (NTPC), Central Building Research Institute (CBRI) [6] have developed technologies for fly ash utilisation, and in particular fly ash-brick making process. Institute for Solid Waste Research and Ecological Balance, Visakhapatnam has developed technology of patented Fal-G cement, bricks, and blocks. This is gaining popularity in and around Visakhapatnam.

1.4 PRESENTATION OF THE STUDIES CARRIED OUT

The studies carried out in this investigation are presented in various chapters as detailed below:

(i) In Chapter II, various methods adopted so far in designing PFA concrete mixes and other studies cared out on the performance of fresh and hardened PFA concretes have been reviewed.

(ii) In Chapter III, the testing programme of the proposed studies on strength and rebar corrosion resisting behaviour of PFA concrete have been presented.

(iii) In Chapter IV, the experimental results have been presented and discussed.

(iv) In Chapter V, life span assessment of PFA concrete has been presented.

(v) The conclusions are given in Chapter VI.

Table1.1 Industrial Wastes (1993) with their Potential

Waste	Industry	Production (Mt / year)	Applications
Fly ash	Thermal power stations	40	Portland pozzolana cement, bricks, ready mixed PFA concrete, building units, sintered fly ash aggregate, lime fly ash cellular concrete, portland cement clinker, oil well cement and masonry cement.
Blast furnace slag	Iron and steel industries	10	Slag cement.
Phospho-gypsum	Fertiliser, phosphoric acid, hydrofluoric acid industries	11	Gypsum boards and blocks, cement clinker and super sulphate cement.
Lime sludge	Paper, sugar, fertiliser, acetylene and tannery industries	4.8	Masonry cement, sand-lime bricks and lime pozzolana mixture.
Cinder	Thermal power stations and rail ways using lump coal	3	Lime cinder mortar and concrete building blocks.
Mine tilings	Zinc, copper and iron ore benefaction plants	6	Calcium-silicate bricks and masonry cement.
Red mud	Aluminium industry	4	Bricks, tiles, light weight structural blocks and roofing sheets.

Lime kiln rejects	Lime kilns	3	Masonry cement
Coal washery	Coal washeries	3	Bricks, light weight aggregate and fuel substitute in brick burning.
Condensed silica fume (CSF)	Silicon metal and ferro-silicon industries	*	High strength and high performance concretes.
Rice husk ash	Rice mills	20	**

* Availability from the Indian industries is not known to the author.

** If rice husk is burnt in controlled conditions, it can produce high reactive pozzolanic ash which may be used for making high strength concretes. Field burnt ash will have large non-reactive silica minerals.

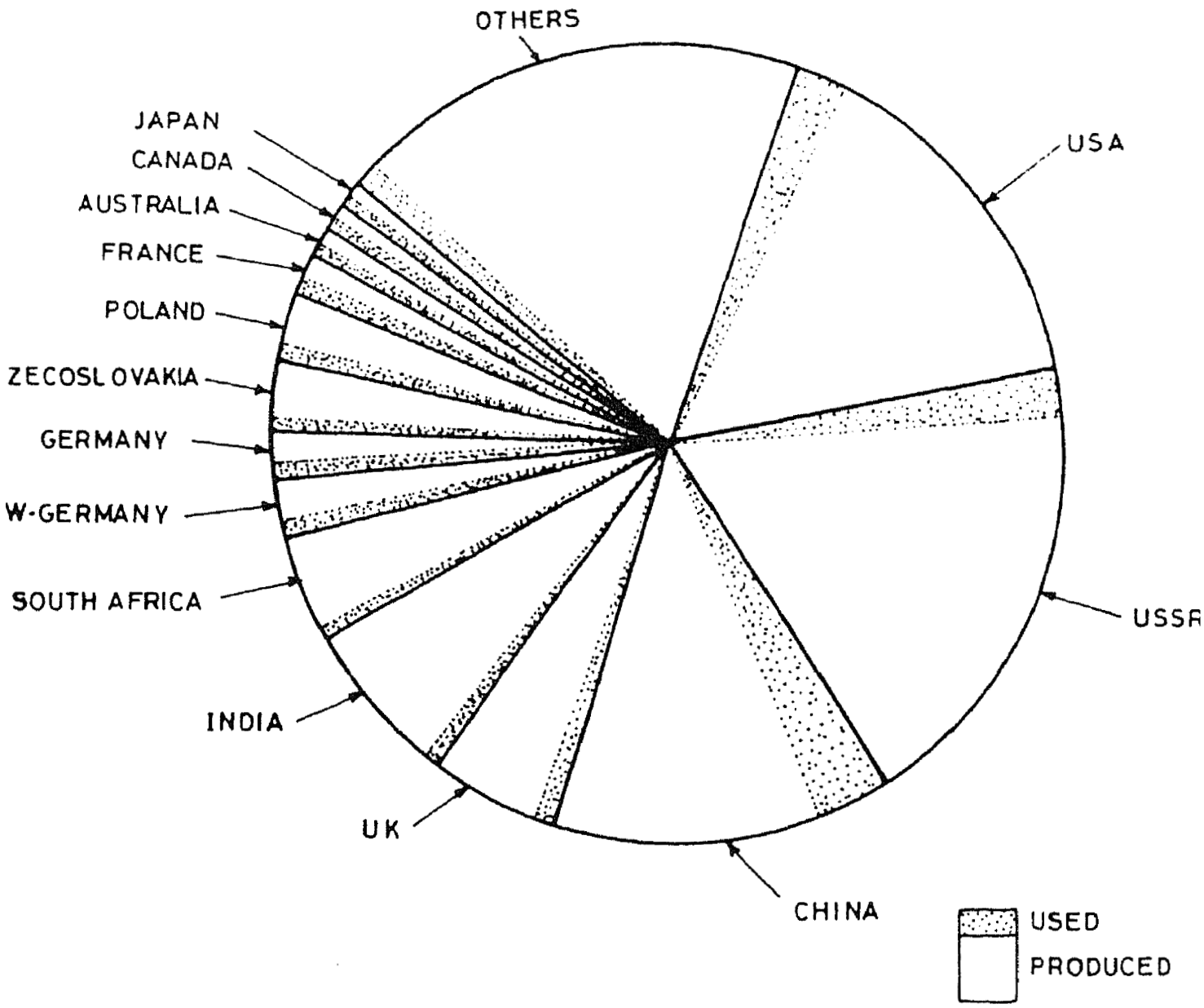

FIG.1·1 World Wide Annual Production of PFA and Its Use in Cement Concrete [5]