ashes with those of soils, without any change in the shape of the compaction curves. The study of compaction curves of coal ashes indicates the following;

- Compaction curves of coal ashes resemble those of cohesion-less soils.
- Compaction curves of coal ashes are relatively flatter indicating that they are water insensitive
- Most of the coal ashes have slightly higher or equal dry unit weights in the air-dried state (*i.e.*, w = 0 or negligibly small) compared with their maximum dry unit weights at OMC.
- The compaction curve of Neyveli fly ash, which is a class C fly ash, occupies the lowest position with least γ_{dmax} and maximum OMC. This could be attributed to the increased resistance offered by the pozzolanic reaction compounds that are developed during the mixing stage itself to the external compactive effect, even though mixing time is minimum. Pozzolanic reaction starts during the mixing process itself.

Higher dry unit weight at the air-dried state can be attributed to the fact that the resistance to the compaction arises out of only inter-particle friction in a two-phase system. With the addition of water, the surface tension forces offer additional resistance to compaction. However, compaction of the coal ashes in the constructional activities can not be recommended to be done at the air-dried state, as it generates enormous amount of dust, causing pollution as well as health problems to the field personnel. Instead, the compaction of coal ashes is recommended to be done at dry of optimum, as compaction of coal ashes is, by and large, water insensitive and the water used during compaction just takes care of the dust problem. The resulting dry unit weight may be slightly lower than the dry unit weight at the air-dried compacted state or at the Proctor's optimum state. However, this is not of serious concern, as the coal ashes have good strengths even in the loose state also (Sridharan *et al.*, 1998b). However, sufficient precaution must be exercised while compacting the coal ashes, as they may have collapse potential when compacted on the dry side of optimum and inundated later. A discussion on the collapse characteristics of coal ashes is given in sec 4.2.5. In order to have a feel for the degree of compaction achieved, the maximum dry unit weights obtained from the compaction test can be compared with the dry unit weights of coal ashes in their loosest state (γ_{dmin}). γ_{dmin} of coal ashes can be determined by slowly pouring the oven-dried coal ash sample in to a cylinder of known volume (65 mm diameter and 106 mm height) through a spout. The position of the spout is so adjusted as to have 20 mm height of free fall of the coal ash. The cylinder is filled with coal ash approximately 20 mm above its top. The excess material above the top is scrapped off using a steel straight edge in one continuous pass. By knowing the weight of the coal ash contained in the cylinder, its minimum dry unit weight can be calculated.

Table 4.4: Compaction characteristics of typical bottom ashes from USA (*data source*: Seals *et al.*, 1972)

No.	Source	G	γ_{dmin}: kN/m^3	Standard Proctor compaction OMC : %	Standard Proctor compaction γ_{dmax}: kN/m^3
1.	Fort Martin (Unit No. 2)	2.48	9.55 (10.20)	24.8 (23.20)	13.08 (13.98)
2.	Kammer	2.72	13.58 (13.23)	13.8 (14.2)	15.70 (15.30)
3.	Kanawha river	2.28	7.65 (8.89)	26.2 (22.5)	11.17 (12.98)
4.	Mitchell	2.78	13.94 (13.29)	14.6 (15.3)	17.94 (17.10)
5.	Muskingham	2.47	10.91 (11.71)	22.0 (20.5)	14.02 (15.04)
6.	Willow island	2.61	11.80 (11.98)	21.2 (20.9)	14.22 (14.44)
	Range		9.55-13.94 (10.20-13.29)	13.8-26.2 (14.2-23.2)	11.17-17.94 (12.98-17.10)

Note: The values within the parenthesis represent normalised values.

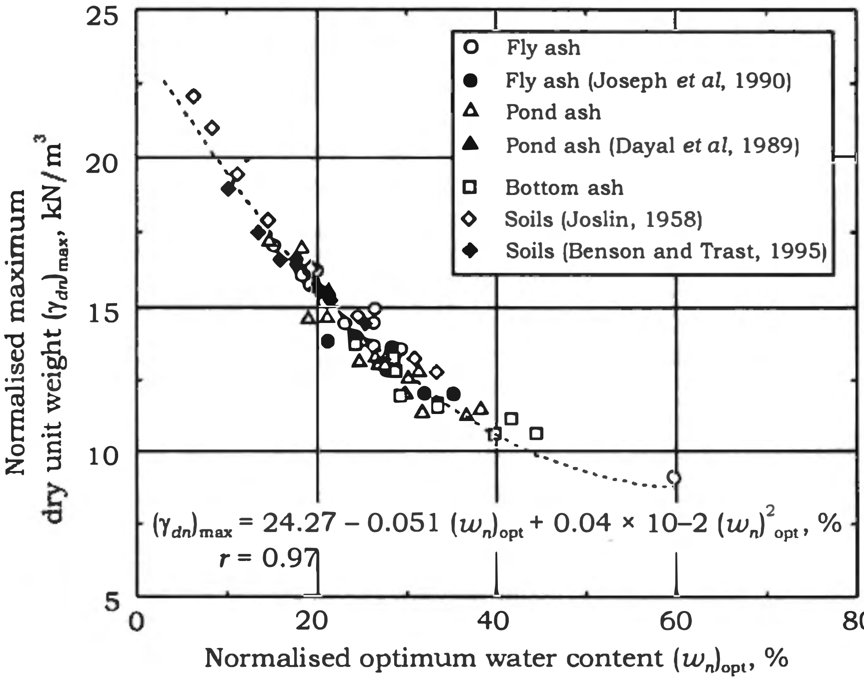

Fig. 4.9. Correlation between normalised Proctor's maximum dry unit weight and normalised OMC for coal ashes and soils (*data source*: Sridharan *et al.*, 2001d)

as effective stress with time is normally known as 'primary consolidation'. The secondary consolidation, also known as creep, is the volume change that results under the sustained loading with time after the primary consolidation is over.

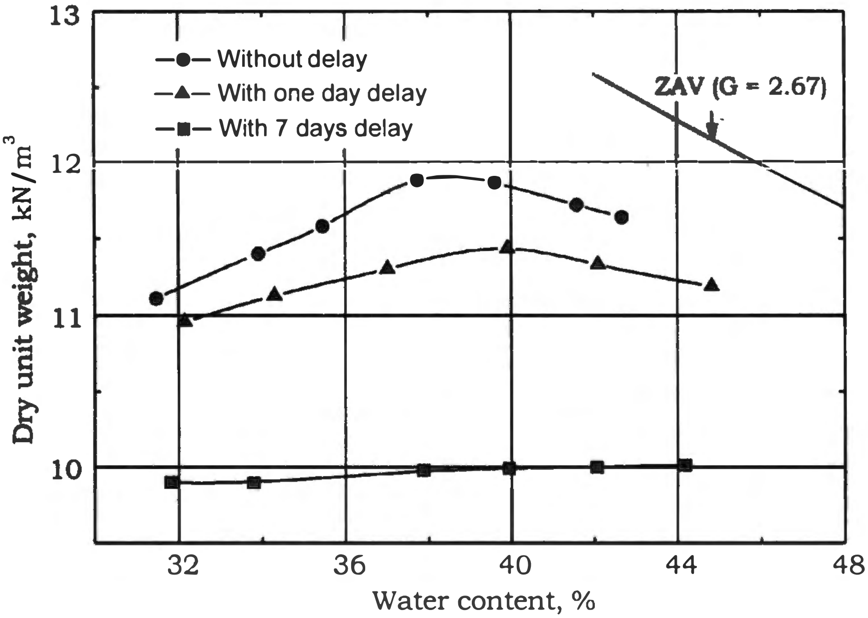

Fig. 4.12. Effect of delay in compaction on the compaction characteristics of pozzolanic fly ash (*data source*: Sivapullaiah *et al.*, 1998a)

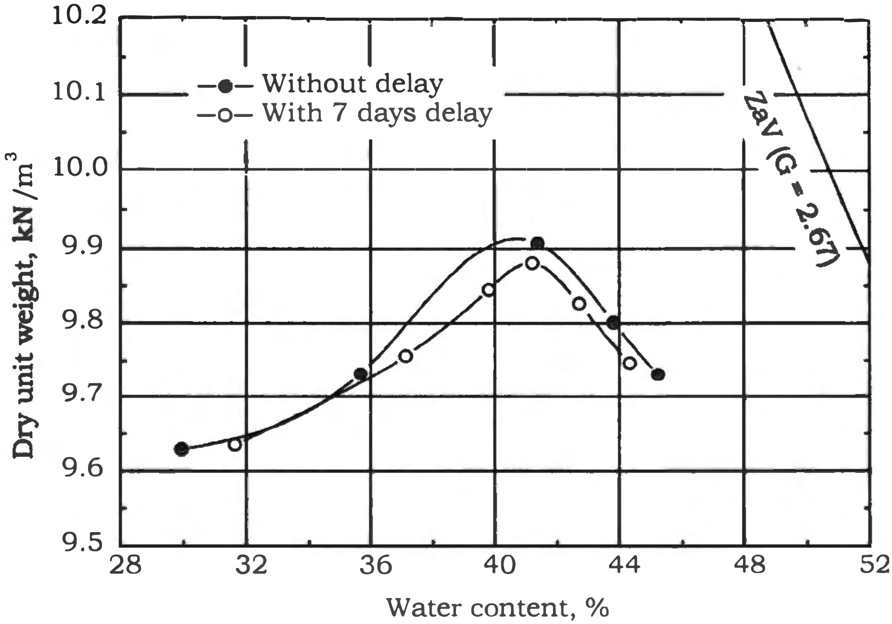

Fig. 4.13. Effect of delay in compaction on the compaction characteristics of non-pozzolanic fly ash (*data source*: Sivapullaiah *et al.*, 1998a)

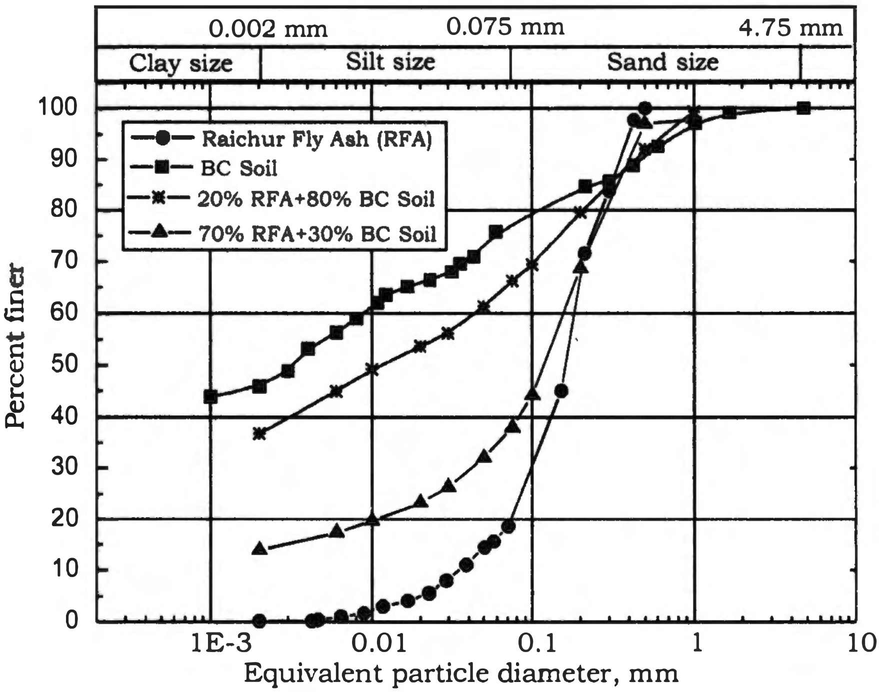

Fig. 5.10b. Grain size distribution curves of BC soil-Raichur fly ash and their mixtures.

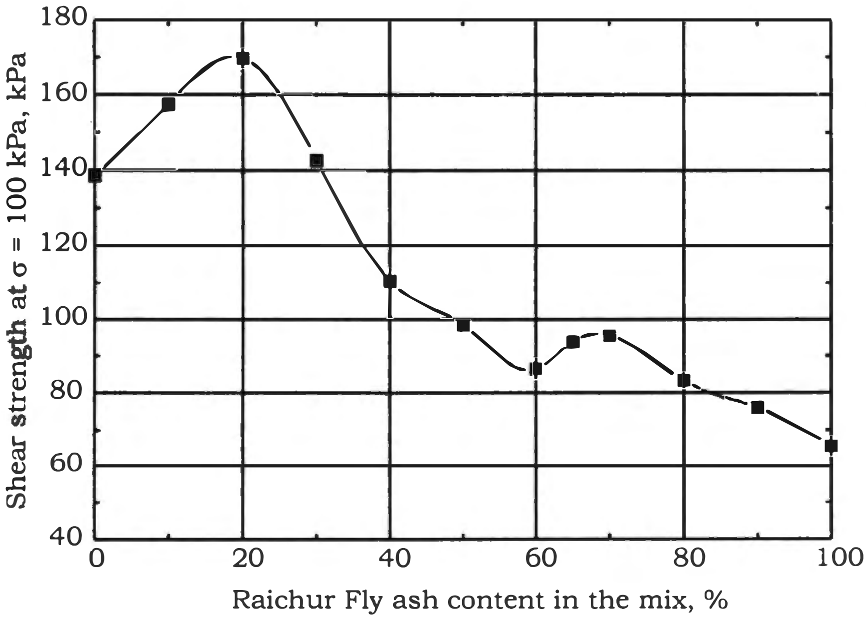

Fig. 5.10c. Variation of box shear strength of BC soil-Raichur fly ash mixtures.