CHAPTER II: SECULAR SPACE
II. 1 HABITATION AND
PUBLIC UTILITY STRUCTURES
II.1 HABITATION AND PUBLIC UTILITY STRUCTURES

The term 'Secular' is used in the present context to simply convey the meaning of that "not involving or belonging to religion". In this sense all those buildings used for non-religious functions and purposes have been placed together for discussion. The indigenous texts perceive secular space in terms of dwellings and public utility structures. The early Brahmanical works refer to such structures through terms like gṛiha, nivāsa for ordinary houses, sālāqāras for stored buildings, kostagāra for granaries, nishādya for rest houses, gōsāla for cattle pens, setubandha for dam, adhara for reservoir, tataka for tank and kupa for well. On the other hand early Buddhist texts have terms such as nāagara for city, arama for garden, nevesana, geha for house, kuti for hut, kottaka for granaries, viṣṇamānasāla for rest house, apana for shop, kilāgāra for sports hall, tadāga for tank, upadana for wells and niddamanā for drains along with different types of building in the above category.

The first part of our discussion is highlighting the various technologies used for habitation buildings. These buildings can be defined as any building used by either an individual or by a community for dwelling or other purposes of communal use. They include, besides the dwelling places, their appendages such as hearths, dumping pits, cattlepenns, granaries or silos, enclosures, shops and pathways. These have been noticed in all Periods of our study (I to IV) which includes the Neolithic, Megalithic, Early Historic, Early Medieval and Medieval levels of
habitation as excavated at various sites of Andhradesa.

As a background to the present study it has been noticed that primitive dwellings of the prehistoric and the early proto historic societies as indicated by the archaeological investigations conducted in the Krishna-Tungabhadra, the Manjira and the Godavari Valleys, has revealed that the earliest palaeolithic human habitations, in some natural form or the other, were concentrated on the banks of the rivers, rivulets and forested areas. This was necessary for the purpose of easy collection of food, as hunting and gathering was the main occupation of the period. In regions outside India like England, France, Italy, Germany and Czecoslovakia, where cold was intense due to long periods of ice fall during the palaeolithic period, man had to resort to living in natural caves and take shelter under overhanging rockshelters. However, so far, no caves of the Palaeolithic period have been reported from India. Some evidence of cave dwelling is evident in the finds of remnants of fossils of human teeth in association with the upper palaeolithic tools from the Billasargam caves of limestone formation in the Nandyala basin in sub-region D of our study.

In the next stage, known as the mesolithic, man was still a hunter, but he made some efforts to make semi-permanent habitations especially on the banks of rivers. Recent excavations conducted at Mucchatla Chintamanugavi, in sub-region D have revealed evidence of a prolonged occupation of the limestone caves by men of the mesolithic period. Besides, some open air sites near Belum, also in the same sub-region, have been located. At Muchchatla Chintamanugavi, the excavations have yielded
some microliths and bones of domesticated animal, at the lower levels. During the mesolithic period, the hunters and gatherers usually had to scout over an extensive territory, exploiting animal and vegetable resources. Since they were on frequent move, they made their shelters from locally available material. The evidence found at the rock shelters and natural caves at Kethavaram and Bollaram in sub-region D, Durgam and Uppair in sub-region A prove beyond doubt that these caves served as temporary shelters during this period. The walls and ceilings of these shelters have been found painted with red ochre and white coloured pigment depicting hunting scenes mainly of animals and some geometrical designs, suggesting their temporary stay. The presence of several rock shelters at Budigepalli, Kadambapur, Regonda, Kokapeta and Gandharikota in sub-region A and Pandavulagutta in sub-region B in association with microliths, neolithic celts and rock paintings, also indicate the occupation of natural protected areas as the earliest habitations of Andhradesa datable to mesolithic times.

The next phase of habitation characterized as the early neolithic, saw a systematic exploitation of flora and fauna and shift in basic subsistence patterns. This led to a tendency to settle more or less permanently at open air locations and to make seasonal migrations to potential open air sites. This phenomena is clearly observed in Period I of our study, when man attained the knowledge of food production. According to Childe this transition from hunting and gathering to food production can best be described as a 'neolithic revolution'. People began to use ground and polished fine grained stone tools. They sometimes moved from caves and rock shelters to open plains specially to cultivate the nearby alluvial soils on the banks of the rivers and rivulets. They cultivated with their
stone hoes, and felled trees with axes and dressed timber with stone chisels and adzes. Binoy Ghosh has proposed three fundamental needs which a human, dwelling served since the dawn of the human society, viz., the need for protection from weather and enemy or wild animals, the need for storing food and tools and the need for free family life. Thus we find that during the neolithic period, people began to live in pits cut into the ground, known in archaeological parlance as pit-dwellings. These have been noticed in many parts of the Indian Subcontinent at Burjahom in Kashmir Valley, Inamgoan in Maharashtra, Piklihal in Karnataka and Paiyampalli in Tamil Nadu. In Andhradesa the pit-dwelling activity has been noticed at Utnoor, Veerapuram, Nagarjunakonda and Gandluru [Chart I A].

After acquiring adequate knowledge in food production, the people had to move to open areas for cultivating fertile lands near river beds. Shelters were made to meet the needs of protection from unfavourable natural climate and to provide comforts which were suitable to varying new environments. With the beginning of settled life in neolithic times, the natural caves became inconvenient since they were located far from the lands that could be potentially used for cultivation. People therefore, moved down to the open air sites where there were no natural caves. It is possible to postulate that in order to suit the environment available in caves, people dug out pits below the ground level. Probably, the cold and windy climate might have also encouraged them to dig pits to use as dwellings. These pit-dwellings not only helped them to be protected from nature but also from predators and enemies from other neighbouring human communities.
As mentioned above, pit-dwelling activity in Andhradesa has been noticed at Utnoor in sub-region A and Veerapuram, Nagarjunakonda and Gandluru in sub-region B. The pits at Veerapuram and Nagarjunakonda were cut into the ground whereas, the ones at Utnoor were only half-subterranean. The plans of the pits varied from circular to oblong and oval at Nagarjunakonda and Veerapuram, pot bellied, cylindrical, shallow, bipartite, tripartite and quadripartite at Gandluru. The measurements of these pits also varied both in diameter and depth from 1.1 to 4.80 metres and 1.20 to 2.0 metres respectively. Some pits were provided with roofings supported by wooden posts, as post-holes on the periphery of the pits have been found at Nagarjunakonda. The mouth of the pits were more or less circular at Nagarjunakonda, Veerapuram and Utnoor and at Gandluru they were neatly dressed. The entrances were made from the natural stone outcrops. This phenomena was observed at Nagarjunakonda. At Gandluru, on the other hand, the entrances were arranged and controlled by some sort of closing, as we noticed here two deep cut post-holes meant for wooden posts. The pits were cut into the natural disintegrated shale deposits at Nagarjunakonda and into the calcareous schist at Gandluru. The pits at Veerapuram and Utnoor were dug into the soils. Some pits were used as soakage or refuge deposits as at Gandluru. Other accessories of the pit-dwellings included hearths, fireplaces, and cattlepens. Cattlepens with wooden barricades near the pit-dwellings have been reported from Utnoor. The bottom of the pits at Gandluru were expanded to facilitate room for cooking and this is indicated by the existence of hearths here. At Nagarjunakonda, the occurrence of dwelling pits in an alignment and also in clusters suggests the existence of both small and extended family units that lived in them.
To cut the pits into the bed rock the technology used must have employed different types of tools of dolerite like pointed chisels, adzes and celts. The sides of the pits at Gandluru were found smoothened to a neat surface. The floors here were somewhat levelled and sometimes dressed neatly, over which a thin coat of lime and earth mixed layer was applied. It seems that they had felt the inconvenience of dampness on the floors of the pit-dwellings and this was probably the reason that led them to lay neat floors of lime and earth.

The early builders opted for only circular or oblong shaped pits since that was the only plan that could be easily excavated as the cutting was in all probability done from inside the pits. Absence of metal tools and with only primitive tools of stone to cut them it was not possible to make shapes with angles at this stage. In order to be protected from the sun and cold, they made some roofings of skin or thatched material supported by wooden posts. All the sites with pit-dwellings have attested the existence of postholes on the periphery of the pits. At Nagarjunakonda, a development in technology can be seen in that the natural rock-boulders were made use of as entrances to the pit-dwellings.

The above discussion reveals that during the early neolithic period people lived in subterranean and deep cut pits into the ground in the shapes which ranged from circular to oval. In all the above mentioned cases, these pit-dwellings were located within the vicinity of water sources. The pits at Veerapuram and Nagarjunakonda were just on the bank of the river Krishna, whereas, at Gandluru they were near the perennial
water rivulet called *Gundlakamma*. The necessity of sufficient accommodation in pits made people expand the size of pits to house four or five people at a time and also to provide space to cook food. Thus fire places and hearths were built within the pits. The pits were provided with steps and the side walls were neatly dressed, the floors were laid with lime *plaster* and finally, they were all covered by some sort of roofing supported by wooden posts.

In contiguous regions to ancient *Andhradeśa* the evidence of pit-dwelling activity at *Inamgaon* in Maharashtra is datable to c.1600-1400 B.C., at Tekkalakota and Sanganakallu in Karnataka, it is datable to 1300 B.C. at *Paiyampalli* in Tamil Nadu, it is datable to 1100 B.C. These are all later than the evidence found at *Utnoor*, which is datable to 2100 B.C. The evidence from all the above sites suggests that pit-dwellings tended to be square and rectangular and then gradually changed to being circular and oval. This is in contrast to what is found in *Andhradeśa*, as here, only the latter type of shapes were preferred. The fact that the early neolithic man had no knowledge of geometrical calculations for making pits, along with his primitive tool kit impeded him to obtain angles more accurately. Similar pit-dwelling activity was also noticed at *Paiyampalli* in Tamil Nadu where the floors of the pits were rammed with fine earth. The pits here were provided with approaches by raising ramps at the entrances. One of these pits was partitioned by planting a row of stones. The postholes around the periphery further indicate conical thatched roofs.

A change occurred in the plans and shapes of the pit-dwellings from being circular to square or rectangular. The pit-dwelling activity
discussed above symbolises the earliest human endeavour in building technology. This entailed either digging or cutting into natural soil while making the natural boulders as entrances. These efforts successfully created an artificial living environment though with minimal facilities. Nonetheless, this enabled man to discard living in natural caves, caverns and rock-shelters. Therefore, it can be looked upon as a land mark in the initial experiments in building technology of habitations in early Andhradesa. However, as proposed by Muller-Wille, based on his theory on duration of early site occupations, it afforded people an opportunity to stay at a site only for some months.

In Period I of our study the evolution of building technology of the early habitation buildings and public utility related structures is effected by new technological discoveries of the neolithic-chalcolithic phase in early Andhradesa. Some new elements such as technique of painting on redware, preparation of parallel sided blades with cristed ridge technique, copper metallurgy, channeled lipped bowls in greyware, and other such material traits got merged into the main stream of the existing early neolithic culture, which came to be defined as the neolithic-chalcolithic culture in the Deccan. These technological innovations changed the very structure of the society. The people discarded living in pit-dwellings and began building houses on hill tops, slopes, as well as on the plains.

This, led to the process of first building houses with perishable material and there is now a concern to build houses above the ground rather than under the ground. In the mature phases of a neolithic-chalcolithic culture, building of houses on the top of the granite hills
or, on the levelled surfaces of hills or at the foot of hillocks became common. This has been noticed at Budidapadu in sub-region A, Nagarjunakonda in sub-region B, Palavoy and Ramapuram in sub-region D. The contiguous regions to ancient Andhradesa have also been reported with similar activity of building dwellings at Piklihal and Tekkalakota, in the neighbouring state of Karnataka. During the megalithic phase of period I the early farming and pastoral communities introduced the use of iron resulting in a total change in the social setup which unleashed new economic processes that culminated in urbanisation during the early historic period. The intensified exploitation of iron ore and the smelting of iron led to the manufacture of sophisticated tools and these could be fruitfully employed for quarrying and dressing monolith stone. This, in turn, facilitated the people to build structures in stone which is a notable change that occurred during this phase. While this meant that the buildings were constructed with non-perishable materials such as stone, perishable materials like mud, reeds and so on continued to be used side by side for floor, roofings, etc. The introduction of iron technology was linked to the spread of agrarian settlements which also meant that permanent houses became a form of housing desired by most people. However, it has been pointed out by A. Ghosh, "the megalithic builders spent all their masonoic skill on building monuments for the dead but none on providing firm houses for the living. This illustrates the point that mere possession of technology does not lead to its application to all spheres, unless it is encouraged by social institutions which can take advantage of that technology". These iron age settlements were largely concentrated on river banks and sometimes, were located near irrigation tanks which were built as seen at Budgepalli in sub-region A. Though data on dwellings for the megalithic phase is limited, we do find information on associated
structures such as platforms, hearths, floors and enclosure walls. Funerary structures of this period are discussed by us separately in Chapter IV.1.

The evolution of building technology in all these phases of Period I can be studied under the classification of: (1) habitation buildings, i.e., dwellings and their appendages such as hearths, cattlepens, barricades, enclosures and (2) public utility structures such as pathways, though the latter are not found on a large scale. Evidences of house building activity during the neolithic and neolithic-chalcolithic phases, has been reported from Utnoor, Chinnamarur, Hulikal, Budidapadu, and Chagatur in sub-region A; Veerapuram, Nagarjunakonda and Gandluru in sub-region B; at Jami in sub-region C and at Palavoy and Ramapuram in sub-region D. Most of the habitations and house buildings of the megalithic phase were more or less on elevated places or river banks as noticed at Serupalli, Pydigutta, Chinnamarur Peddamarur and Polakonda in sub-region A; Veerapuram and Gandluru in sub-region B and at Ramapuram in sub-region D [Hap V and Chart I A].

The houses of the first phase of period I were built of local materials, which played a considerable role in determining the plan and construction of the buildings in geometrical pattern. The houses were either circular, square or rectangular in shape, floors were rammed with earth and morrum and then smeared with cow dung. Sometimes, they were planted with lime on stone chips mixed with earth and laid as a layer. Posts were planted on the periphery of the floor to support the roofs. Enclosures were provided on all the cardinal directions and these varied in each case. Walls were built of mud, wattle and daub. Hearths and fire
MAP-V

DISTRIBUTION OF HABITATION AND PUBLIC UTILITY STRUCTURES PERIOD WISE
### CHART I A

**Period I: Habitation and Public Utility Structures**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Name of the Site</th>
<th>Sub-region</th>
<th>Type of House Plan</th>
<th>Foundations/Floors</th>
<th>Post-Holes</th>
<th>Walls</th>
<th>Roofs</th>
<th>Associated Structures</th>
<th>Public Utility Structures</th>
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<td>1</td>
<td>Budidapadu</td>
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<td>Chagatur</td>
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<td>Chinnamarur</td>
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<td>4</td>
<td>Gandaluuru</td>
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<td>8</td>
<td>Palavoy</td>
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<td>9</td>
<td>Peddabankur</td>
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<td>10</td>
<td>Peddamarur</td>
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<td>11</td>
<td>Polakonda</td>
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<td>12</td>
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<td>Serupalle</td>
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<td>15</td>
<td>Veerapuram</td>
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<table>
<thead>
<tr>
<th>Type of House Plan</th>
<th>Foundations</th>
<th>Walls</th>
<th>Roof</th>
<th>Associated Structures</th>
<th>Public Utility Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>U Pit-dwelling</td>
<td>☐ Mud</td>
<td>☐ Mud</td>
<td>/ \ Thatch</td>
<td>O Hearth</td>
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<td>O Circular, Semi-circular, Oblong</td>
<td>○ Concrete</td>
<td>•• Brick</td>
<td>➔ Tile</td>
<td>Platform</td>
<td>$ Workshop</td>
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<td>... Plastered</td>
<td>☐ Stone</td>
<td>☐ Stone</td>
<td>= Granery</td>
<td>= Wharf</td>
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<td>X Square</td>
<td>☐ Stone</td>
<td></td>
<td></td>
<td># Well</td>
<td>ANT Amphitheatre</td>
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<tr>
<td>T Rectangular</td>
<td>¬ Rock</td>
<td></td>
<td></td>
<td># Drainage</td>
<td>ST Stadium</td>
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</tbody>
</table>

( ) Cattle penn  BG Bathing Ghat
[ ] Compound Well  RH Rest Houses
places were built inside the houses. Sometimes, houses were arranged in a linear pattern and occasionally, they were clustered. Well laid pathways have been noticed for the first time belonging to neolithic-chalcolithic period. The periphery of the houses was planted with stone slabs as a sort of border. Central posts supporting conical shaped roofs have also been noticed. It is well-known that technology and the availability of raw materials were closely inter-related as they affected the methods of house building. The plans of houses of the neolithic and neolithic-chalcolithic phases on circular plan have been reported from Chinnamarur, Veerapuram, Hulikal, Budidapadu, Jami, Chagatur, Palavoy and Ramapuram [Plate I]. At Chagatur and Gandlur, a semicircular plan of houses was also encountered. Plans of oblong houses have been seen at Veerapuram, Chinnamarur and Ramapuram. The houses constructed on square plan have been reported from Nagarjunakonda only. The rectangular plan was preferred at Utnoor, Nagarjunakonda, Gandlur and Palavoy [Chart I A]. The foregoing information leads us to observe that there was a change in house plans from circular to square and rectangular. It has been suggested that this indicates that gradually the sedentary life of the agro-pastoral communities began to become permanent in nature. In such a situation people preferred square and rectangular structures whereas the earlier communities having to migrate on a seasonal basis were accustomed to the circular plans.

The plans of the houses of the megalithic phase were both circular and rectangular. The circular hutments were noticed at Serupalli [Plate II], Veerapuram, Chinnamarur, Peddamarur and Polakonda. Semi-circular ones were also in existence as noticed at Pydigutta. A lone example with an apsidal
Period I: A circular hut, Neolithic Phase, Hulikal, Sub-region A

Period I: A hutment, Neolithic - Chalcolithic Phase, Chinnamarur,
plan has been found at Ramapuram. The rectangular plans were found preferred at Veerapuram and Gandluru [Chart I A]. In this connection it is appropriate to recall that in the neolithic period too there was a coexistence of all these plans. Scholars like Kent V.Flannery opine that "circular dwellings tend to correlate with nomadic or semi-nomadic societies, rectangular dwellings tend to correlate with fully sedentary societies". Circular or oval hutments are raised even today by the Chenchus of Amrabad-Mannanur valley and circular hutments are used in the coastal areas of Andhra Pradesh. The tribal people pitch up their seasonal camps by way of erecting the posts in a circular fashion. In the coastal area the circular houses were especially preferred so as to withstand the powerful winds of the coasts [Figure 3].

The contiguous regions of ancient Andhradesa also provide important evidence of house building activity which were supported by postholes as noticed at Naikund in Maharashtra, Brahmagiri, Maski and Hallur in Karnataka and Paiyampalli in Tamil Nadu. Wooden posts were usually put into the dug out holes by dressing the bases with stone chisels, but at Chagatur, the posts were driven and erected into the holes cut into the bedrock. The posts were made of wood of the Acasia or Dalbergia species. They were earlier circular in shape but one finds square and rectangular ones as well. The latter implies that the bases of these posts were chiselled by the early carpenters in this way because they offered more firmness than the circular ones. They varied from 20 to 80 centimetres in diameter and 14 to 36 centimetres in depth as noticed at Palavoy. Interestingly, at Chinnamarur [Chart I A.3], a shale stone of size 75 x 70 centimetres was kept at the centre of the hut, probably to serve as a base.
A modern hut with conical thatched roof, Visakhapatnam, Sub-region C
(Reproduced from Census of India, 1961, Vol.II, Part IV-A Delhi, 1964, Sketch No.3)
for a central pole supporting the frame of a conical roof. The stone at the base must have been put to counter the dampness of the black cotton soil here and to see that the base of this lone post which being the main support to the entire hut, was protected from insects like termites, etc. This also reveals that they learnt from their earlier experience based on observation when building materials, particularly wood must have deteriorated and therefore, precautionary measures had to be taken to rectify this. Thus, technological improvements in the erection of wooden posts has been observed during the megalithic phase. Dwellings at places like Serupalle, Veerapuram and Peddabankur were all supported by wooden posts. An interesting feature to note in this context is two unique postholes at the entrance of a circular hutment at Serupalle. Their base was strengthened by the insertion of quartz pebbles. This was in all probability meant to not only provide additional support for the wooden posts so that they would last long, but they did so without tilting to sides. This feature can be said to have been a significant improvement to the earlier methods of erecting posts, affording a longer duration to withstand wind and other pressures.

No major changes in the types, plans and building materials used for constructing ordinary dwellings during the megalithic phase have been noticed by us. More or less the same types and plans described for the neolithic phase continued with marginal changes in the appendages that were added to the houses. However, a combination of perishable and non-perishable materials such as stone, wattle and daub were used together and these structures were supported by the wooden posts and mud walls. The roofs continued to be made of vegetable materials as was done in Neolithic
times. The floors were rammed and sometimes lime plastered. It has been observed by us, that to make stone paved floors, was an innovation of the period. Further, for the first time, houses were enclosed by compound walls. The settlements were still dependent on natural water sources only. Therefore, so far no evidence of using ground water has come to light for megalithic levels of habitation.

The megalithic people in Andhradesa like those in other parts of South India lived in these simple dwellings though evidence of these habitation sites is not very prolific. It must therefore, be stated that despite an economically stable background, coupled with a growth of agricultural settlements and the spread of iron technology, there was no major breakthrough during megalithic times in transferring technological skills of making houses to ordinary people nor did it give rise to major public utility structures.

The walls and the roofs of these dwellings were supported by wooden posts as postholes have been found on the periphery of the floors of the dwellings. Postholes of the neolithic phase have been found at Hulikal [Plate I], Nagarjunakonda, Jami, Palavoy, Ramapuram [Chart I A],

The walls of the dwellings of the neolithic, neolithic-chalcolithic and megalithic phases were mostly built of mud. Later, these were perfected by wattle and daub and a further evolution of building technology was observed in building them with non-perishable material such as stone. The walls of the dwellings in the contiguous regions of Karnataka were made of split bamboo mattings, plastered with mud and cowdung, supported at intervals by wooden posts, as seen at Piklihal and Tekkalakota. The
periphery of the houses were sometimes planted with shale stones placed vertically to demarcate the circular plan. These probably served the purpose of preventing the unwanted entry of insects. This feature has particularly been noticed at Chinnamarur and Budidapadu. At Ramapuram and Hulikal on the other hand, the stone pieces were erected vertically inside the already dug out shallow channels and care was taken to prevent the entry of snakes by digging snake pits. A further development in this aspect has been noticed at Palavoy, where unhewn granite boulders of considerable size were placed around the floors of the houses. They were collected and brought from nearby areas not only to demarcate but also to protect the house from big predators and human enemies. As a stage in the evolution of human societies when the first ranked and stratified society had emerged it necessarily meant that signs of conflict and warfare had become apparent. Therefore, protection against enemy communities began to emerge in the settlement area. In the last phase, i.e. in the megalithic context, the houses were buttressed with stone slabs. The walls more or less, continued to be built in the same manner as noticed in the neolithic phase. The walls at Polakonda located in sub-region B were made of mud and rubble. This indicates no significant change in the building of walls of the megalithic phase.

The roofs of dwellings were probably made of vegetable material during the neolithic period. The plan of the structure at Chinnamarur which suggests a conical roof, was in all probability made of reed and grass bundles, tied to the top end of the pole to form a cone [Chart I A.3]. The sloppy sides facilitated draining off the rain water beyond the periphery of the mud wall. The early builders took keen interest to protect their
mud walls, as which otherwise they would have demanded frequent repairs after the rainy season. This arrangement can be said to be an important achievement of the early building technology. Vitruvius, the famous engineer of Italy who flourished during the early centuries of Christian era, has summed up man's earliest efforts in house construction in the following way. "Some of them began to make roofs of leaves. Others, to dig out caves under the hills, some imitating the nests and constructions of swallows made places into which they might go; out of mud and twigs. Finding then other shelters and inventing new things by their power of thought, they built in time better dwellings. At the beginning, they put up rough spares, interwove them with twigs and finished the walls with mud".

The floors of the houses of the neolithic period were rammed with clay nodules, morrum and occasionally, were plastered with mud and lime concretions. Paved floors with shale stones were also innovated. Floors of rammed earth have been noticed at Chinnamarur, Hulikal and Ramapuram. At the last site, the floors were raised above the surrounding ground level, by digging out earth from outside the hutments. Floors were also rammed on the calcareous nodules and stone chips at the above sites. It was only at Chinnamarur that rubble floors have been encountered. The floors were found plastered with clay at Chagatur. Further a pavement of cut shale stone for floors was noticed at Ramapuram. The areas outside the hutments were also paved similarly, probably to be used as working places for domestic purposes. This arrangement of raising the floor level, levelling the surfaces, paving chips and then ramming after which a pavement was made of shale stone all bespeaks of their knowledge in keeping the floors at a higher level so as to be water proof.
This highlights an aspect of a sound technological achievement of this early period of human habitation.

During megalithic phase, the floors of the dwelling places were rammed and then made up of shale stone chips and plastered with lime stone concretions as found at Chinnamarur. A similar feature was noticed also at Hallur in the neighbouring Karnataka. A further improvement in laying the flooring has been observed at Serupalli [Plate II] where cut shale stone slabs were paved in two courses in order to protect the house floor from dampness, since this site was located on sticky black cotton soil. The surface was treated with a thick layer, mixed with shale stone chips and mud, to achieve firmness. This was a well-known practice of those times and in Tamil Nadu. At the site of Paiyampalli, we find that circular houses also had such floors, made of stone chips covered with morrum and plastered with lime.

The neolithic people had some amenities both inside and outside the habitational buildings such as hearths or fire places, facilitating them to cook food and refuge pits to dump the waste which were dug just near the huts. Besides these, some appendages to the dwellings such as cattlepenns or stockades were also built with a simple technology geared to easy access and use. The associated structures, found along with dwellings of the megalithic period include platforms, built for different purposes, and granaries. The public utility related structures of the late neolithic period are rare and we find evidence of only a pathway in the habitational area. Construction of compound walls surrounding a group of houses in
Period I: Circular pattern of hut with stone floor, Megalithic phase Serupalli, Sub-region A
The megalithic phase was a new aspect of community protection which was not known earlier.

The hearths were single, double and sometimes complex ones found in large number. Some denote that more than one pot would be kept at a time with a minimum of two varieties, so that cooking could go on simultaneously. This, not only saved a lot of time, but also indicates that large families probably lived together. Saving time on domestic work was in any case important, as, during this early period both the agricultural and pastoral activity used community based labour. The family was therefore, required to work for long hours outside the house.

At Chinnamarur, the hearths were noticed in the south-west direction. They were built with cut shale stones, which were planted vertically to earthen hearths to a height of 36 cms. probably to protect the circular hearths from the gale. This technique was also employed because, with the help of vast experience in making use of the fire, they wanted to conserve the heat and not let it go waste. In another hut at the same site, the hearths were formed by arranging shale stone pieces. At Jami, a double hearth looking like twin basins sunk into the ground has been found. Some more interesting information comes from Ramapuram, where the hearths of burnt clay had a separate fuel chamber and a deep fire place with tripods. It also had a side oven connected by a small tapering hole. Two pots could be kept on this and the cooking done simultaneously. Clay lined hearths and fire places have also been noticed at Gandluru and Veerapuram [Chart I A]. The above information leads us to conclude that the neolithic people had their fire places made of clay lumps in the
beginning which were then improved technologically by lining them with stones. Still later, inorder to offer permanancy, the shale slabs were planted to protect the hearth. This also helped to utilise the fire to the maximum extent. Necessity was the prime motive force to bring about these innovations. Their sound knowledge in building technology is also indicated in the expert way in which the fire places were made with single and double hearths, which were provided with separate fire chambers.

Some shallow pits dug outside the houses were meant for dumping the waste and other used material during the neolithic period. This also can be said as an important aspect of the early building technology to keep the habitation areas clean and maintain good sanitary conditions. The chief evidence regarding this aspect comes from Nagarjunakonda and Gandluru, where pits were cut into the ground and these were found during the course of excavations to be containing waste material.

Plans of cattlepenns, denoting the importance of the upkeep and management of domesticated animals come from Utnoor and Nagarjunakonda. At Utnoor in the neolithic settlement, a double line of postholes of 9" in diameter with an interval measurement of 1'-0 to 2'-0 in between two poles has been noticed, indicating a stockade. Occurrence of postholes in front of the stockades implies a verandah or an area used to reinforce struts set at greater interval, denoting some sort of wooden barricade for the small cattlepenns. This type of evidence proves that the neolithic people were masters at not only building dwellings for themselves but also equally responsible for building wooden barricades to facilitate some sort of protection for the cattle from wild animals. They also had to see that they were not let loose to cause damage to the crops which, in a mixed
farming economy were also being raised by the people.

Among the prominent associated structures or appendages to the megalithic dwelling units figure platforms which were built both inside and outside the house. They were probably used to keep household objects of daily use and have been noticed in particular at Ramapuram. Granaries, circular and oval shaped, dug to a depth of 10 to 35 cms. and then rammed with white sticky clay, have also been found at Ramapuram. Sometimes, stone slabs have been seen projecting out from the pit, to serve as bases for the thatched bins and these have been recorded at Ramapuram. A very significant and unusual find for this period is the occurrence of mud bricks of size 30 x 17 cms. at Gandluru in the context of a dwelling [Chart I A.4]. This is for the first time that sun-dried bricks have been discovered from a late phase of the megalithic period. The houses built with these bricks were rectangular in plan. In the evolution of building technology the last phase of Period I is thus marked by the discovery of early brick making technology.

Another significant aspect of the building technology of the megalithic phase was the construction of enclosure walls for clusters of houses, inorder to provide security and protect the habitation from wild animals or from enemy clans and tribes. Two examples have come to light from Chagatur and Chinnamarur [Chart I A.2 & I A.3]. The circular wall at Chagatur was 1.5 metres in thickness. They were built using shale stone slabs enclosing the hutments and found to an extant a height of 1.0 metre. The one that enclosed some houses at Chinnamarur was of 1.00 metre in thickness. Scholars like B.Subrahmanya opine that this sort of building
barricades or enclosure walls should be considered important precursors for the construction of fortifications around settlements found common during the succeeding early historic times in Andhradesa.

The concept of building houses in clusters or groups arose during the neolithic-chalcolithic phase as noticed at Ramapuram. Sites like Chinnamarur, Gandlur, Veerapuram, Hulikal and Nagarjunakonda also had a group of hutments within a limited space of the habitation, indicating the formation of a small village dependant mainly on a small scale agricultural and pastoral economy. According to Bhattacharya the Deccan neolithic houses occurred in small clusters of mud and stone at a time when the western group of such settlements had developed into larger ones which he calls chalcolithic urban centres. In his opinion in the southern Deccan this growth might not have been possible, due to lack of contacts with the developed communities with whom economic exchange could have developed on a large scale. The Western group of the chalcolithic and late neolithic settlements on the other hand, had vigorous cultural contacts with well-developed centres in north-western India. Therefore, with a largely village environment of settlements in proto-historic Andhradesa, we do not have much evidence of public utility structures or monumental buildings. In this connection a very interesting and unique evidence comes from Ramapuram. Here, it has been noticed that a pathway was laid to a length of 40 metres in north-south direction, with a varying width of 2.60 to 3.60 metres. For the first time such a pathway has been found belonging to the neolithic-chalcolithic period in Andhradesa. The roadway was laid with central rib and was found sloping to the sides. The total width was paved with rubble stone which served as a soling to the road, quite similar to the modern way of laying roads. The width of 3.60 metres was quite wide.
probably enabling the movement and crossing over of two carts at a time.

The foregoing part of our discussion on the building technology of the neolithic, neolithic-chalcolithic and megalithic phases of Period I in Andhradesa reveals that the technology used to build in the habitation areas was still in its incipient stage. It gradually took shape with some marked developments in identifying appropriate locations and building materials and these further led to improvements. Amenities inside and outside the dwellings proliferated and wooden structures, for purposes of the domestication of cattle, were not lost sight of indicating the emergence of permanent settlements in these early villages. The distribution pattern of sites in all the sub-regions reveals that the neolithic and chalcolithic people inhabited the fertile areas, often called as the 'areas of attraction' lying on the banks of rivers and rivulets, with a potential to expand agricultural production. These early experiences have been passed on through generations so that many features of the circular plans of houses and the nature of building hearths continue to be known to many nomadic and settlement communities of the Deccan and Andhradesa even today.

The houses built as an immediate precursor to Period I were, pit-dwellings made under the ground. This tendency in the late neolithic and neolithic-chalcolithic phase shifted to build over the ground in varied plans with locally available building materials. The walls were mainly of wattle and daub and sometimes of mud. The same was continued in the last phase known as the megalithic. The roofs were laid using primarily vegetable material such as reed and leaves. Use of unhewn boulders of
granite and shale stone for flooring, hearths with separate fire chambers, digging pits outside the houses to dump the waste were some of the innovative aspects of the habitation areas of this period. Laying of a pathway facilitating easy walk especially during the rainy season was another innovation of the building technology of these early societies. It is important to note that this primitive and simple technology built houses primarily of perishable materials. There was also only a limited exploitation of natural resources in this context and it was primarily wood, reed and other natural grasses that were effectively put to use.

During the megalithic phase, the gradual use of stone emerges. However, during the proto-historic period as a whole, mud and wattle and daub remained the predominant materials for building houses and other structures. For the first time, in a late megalithic phase, sun-dried bricks were manufactured, which were replaced by burnt bricks in building the habitational and other buildings in the succeeding period, i.e., the early historic in Andhradesa.

The evolution of building technology of the habitation and public utility related structures of Period II of our study in Andhradesa begins with a brief introduction on the socio-economic and, i.e., politico-religious changes that took place in early Andhra during in the transition from the proto-historic. The knowledge in metallurgy and other technological advancements achieved in the last phase of proto-historic times paved the way for the manufacture of metal objects and tools, of various sizes and shapes, on a greater scale during Period II. This easy availability tremendously helped in catering to the needs of the common people in building habitational and public utility related structures,
during the early historical times. It has been opined that it was iron technology, rather than changes in the political system, though the latter may also have had its share, which provided the necessary tools for the cultivation of crops and the proliferation of arts and crafts. In the beginning many early historical settlements were not very different from the village settlements of Period I but later, they got transformed into towns. Some of these cities were significantly located along the banks of the major rivers or rivulets and thus provided with alluvial tracts in the vicinity. This led to an increase in agricultural surplus which provided the necessary financial backing for a proliferation of crafts and technological skills. The locale for the latter were the urban centres, which, during this period, were also the major locales for systematic building activity. In this context, Amita Ray has put forth her ideas that improved communication routes, extensive mining operations, the increase in money economy, the establishment of provincial seats of administration and the introduction of Buddhism all created a social situation, which, in turn provided a base for the growth of urban centres in early Ænhradeśa.

In early historic Andhradesa, settlements in the various sub-regions such as Dharanikota, Kotilingala, Satanikota, Veerapuram, Nagarjunakonda were located close to major rivers whereas, the sites like Dhulikatta, Peddabankur, Kondapur and Nelakondapalli were situated in the interior on small rivulets. Some of these were located on important trade routes which meant interlink with developed areas of the region as a whole. A developed town planning has been observed at Dharanikota, Amaravati, Kotilingala, Dhulikatta, and Nagarjunakonda. Some of the early semi-urban settlements retained their traditional agrarian nature while the others emerged into
against this background it is necessary to highlight different types of habitation buildings to understand the level of technological developments during this period and to delineate the various materials used for construction, from roughly about the 4th century B.C. to the 4th century A.D. The settlement patterns show an expansion and the size of the individual structures also increases with several improved facilities in the dwelling houses when compared to habitation structures in Period I. On the whole, the early historical settlements comprised of well-laid out house plans which included common dwellings, building complexes surrounded by enclosures, water supply and sanitary structures, workshops, roads besides public utility constructions such as an amphitheatre, rest houses and public baths and ghats.

The excavations conducted in Andhra Pradesh have revealed many interesting aspects of building technology of this period. The sculptural representations particularly from Amaravati, and the contemporary literature have also supplied ample information to correlate the factual information with the literary descriptions. The habitational structures, primarily meant for dwellings ranged from simple huts to sophisticated dwellings, along with many associated structures. The walls were made either of wattle and daub, mud, brick, or stone. The roofs were either, thatched or, made with brick and stone paved or tiled. The floors were either made of rammed earth, lime plastered, lime concreted or paved with brick and shale. The buildings were raised on simple foundations of rubble stones. Water was drawn from wells sunk into the ground. Storage tanks and brick cisterns were also built within the houses. Waste water was

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taken away by drains both covered and uncovered. To provide smooth spaces for walking and easy transport, a good number of roads intersecting one another and connecting the entire settlement were laid. Public utility structures such as workshops, amphitheatre and public baths were also built during this period. Well-laid out town planning has been observed particularly at Dhulikatta and Nagarjunakonda with almost all amenities available in the cities.

An early Buddhist text, the Milindapanha provides us a clear account of the essential features of building a new town or city. This entailed first and foremost the selection of a good site and ended with laying of roads to ultimately give the habitations and public utility structures a good finish. These textual traditions must have been available to the architects, town planners and engineers of early Andhradesa as many of these ideas are found in cities excavated here. The above cited material is available to us in varying degrees of survival and has been reported from Kotilingala, Dhulikatta, Peddabankur, Kapparaopet, Kondapur, Polakonda, Peddamarur and Kyathur in sub-region A; Veerapuram and Nagarjunakonda in sub-region B; Dharanikota [Map V] and [Chart IB] and Amaravati in sub-region C; and Satankota in sub-region D.

The plans of the different types of dwellings varied from circular to square and rectangular. Circular houses have been reported from Kotilingala, Amaravati and Peddabankur. Rectangular plans have been found at Kotilingala, Kondapur, Satankota, Peddamarur, Kyathur, Veerapuram and Nagarjunakonda [Chart IB]. Houses on square plan have been found seen at
Kotilingala, Satanikota, Kapparaopeta and Nagarjunakona. A typical chatuśśāla variety has been noticed at Dhulikatta and Nagarjunakonda. The Amaravati sculptural reliefs provide some information regarding the plans of the contemporary houses. [Figure 4] The Mattavindaka, Kavikumāra and Somanassa jataka panels illustrate, for us, circular, square and rectangular huts. Royal buildings of two and three stored buildings have also been seen provided with doors, windows, balconies, staircases and compound walls.

The architects of the period had selected suitable sites for raising the housing structures for dwelling. Some houses were built directly over the soils and bedrock while some were laid with good foundations below the ground level, which were arranged in such a manner so as to transmit the loads on the structures to the soils below. This was done in order to prevent unequal levelling of the settlements and also increase the stability of the buildings. The structures at Kondapur and Dharanikota were raised directly on the soil surface and did not have any foundations below the ground level. At Dhulikatta, the houses were built over the well rammed earth since the architects must have observed the instability of settlements laid directly on the soils and thus wanted to provide adequate foundation for the buildings. The foundations for the brick structures below ground level were filled by rubble stones in one or two courses set in mud mortar. Rubble foundations have been noticed at Kotilingala, Dhulikatta, Kapparaopeta, Polakonda, Peddabankur, Kyathur and Nagarjunakonda [Chart IB]. At Kyathur, the foundations were laid from natural morrum level. At Peddabankur and Satanikota the natural bed rock served both as a foundations and basement to the buildings. The architects selected such a site for building activity keeping in view, the fact that
FIGURE 4

(a) A hut from Kavikumara Jataka (b) A hut with matted walls (c) A hut with doors

(d) A Rectangular hut from Kavikumara Jataka (e) A Parnasala or hut with a thatched roof. (f) A hut from Mattavindaka Jataka

Sketches of huts from sculptural reliefs on panels found at Amaravati, Sub-region C

(Reproduced from A. Ray, Villages, Towns and Secular Buildings in Ancient India, Calcutta, 1964, Figs. 12, 11, 6, 26, 28 and 10)
## CHART I B

**Period II: Habitation and Public Utility Structures**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Name of the Site</th>
<th>Sub-region</th>
<th>Type of House Plan</th>
<th>Foundations/Floors</th>
<th>Post-Holes</th>
<th>Walls</th>
<th>Roofs</th>
<th>Associated Structures</th>
<th>Public Utility Structures</th>
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<tbody>
<tr>
<td>1.</td>
<td>Amaravati</td>
<td>C</td>
<td>D</td>
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<td>BG</td>
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<td>Dharanikota</td>
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<td>4.</td>
<td>Dhulikatta</td>
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<td>5.</td>
<td>Kapparapet</td>
<td>A</td>
<td>X</td>
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<td>B B</td>
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<td>6.</td>
<td>Kondapur</td>
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<td>Kotilingana</td>
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<td>B B</td>
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<td>8.</td>
<td>Kyathur</td>
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<td>Nagarjunakonda</td>
<td>B</td>
<td>X T Z</td>
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<td>B B</td>
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<td>$, AMT, ST, RH, BG</td>
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<tr>
<td>11.</td>
<td>Peddabankur</td>
<td>A</td>
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<td>B</td>
<td>X</td>
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<td>T A</td>
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<td>III</td>
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<td>B</td>
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<td>BG</td>
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<tr>
<td>Type of House Plan</td>
<td>Foundations</td>
<td>Walls</td>
<td>Roof</td>
<td>Associated Structures</td>
<td>Public Utility Structures</td>
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<td>4 Mud</td>
<td>/\ Thatch</td>
<td>C Hearth</td>
<td>Pathway</td>
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<tr>
<td>Circular, Semi</td>
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<td>4 Brick</td>
<td>4 Tile</td>
<td>- Platform</td>
<td>$ Workshop</td>
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<tr>
<td>circular, Oblong</td>
<td>4 Plastered</td>
<td>4 Stone</td>
<td>4 Stone</td>
<td># Granery</td>
<td>% Wharf</td>
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<tr>
<td>Square</td>
<td>4 Stone</td>
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<td></td>
<td># Well</td>
<td>ANT Amphitheatre</td>
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<tr>
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<td>4 Rock</td>
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<td># Drainage</td>
<td>ST Stadium</td>
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( ) Cattle pen
BG Bathing Ghats
[ ] Compound Wall
RH Rest Houses
the rock bed would act as a raft foundation. At Satanikota, the depth of foundations for another building complex was 0.44 metres filled with morrum and small pellets of Kankar. The rammed packing had served as a firm base for the standing walls as the loose gravels were not suitable for carrying the load of the heavy brick wall. The foundations for the buildings were mostly two or three layers of random rubble stones, set in mud mortar over which the brick or stone walls were constructed as at Nagarjunakonda. The *Miliñdapanha* cited above clearly mentions that the selection of a suitable site before building the structures of a city was needed and this was heeded to by the contemporary architects of the time.

The walls of the habitation buildings of Period II of our study vary from either being wattle and daub or mud walls to brick and rubble walls. Wattle and daub ones have been reported from the *Amaravati* excavations. A wall of wattle and daub with mud and white washed called as *Sudhamattikalepana* has been mentioned in the Buddhist text *Cullavaqqha*. Mud walls, by way of piling or placing wet clay clods to form a wall, have been reported from Peddabankur, Kondapur, Kotilingala and Nagarjunakonda [Chart IB]. *Postholes* have also been noticed on the periphery of walls meant for wooden poles set in mud walls which were needed to support the wooden frames of the thatched roofs.

On the other hand, houses built of bricks have been reported from Kotilingala, Dhulikatta, Peddabankur, Polakonda, Kapparaopeta, Satanikota and Nagarjunakonda [Chart IB]. The lower brick course at Polakonda has an offset of 10 cms. wide projected from the wall serving as plinth or *Kudvyapāda* [Plate III]. This arrangement facilitated the walls to diffuse
the superimposed load onto the ground of the basement. The thickness of
the walls also varied from 0.50 metres to 0.90 metres. At Satanikota and
Polakonda, the width was 0.50 and 0.55 metres whereas, at Dhulikatta and
Kotilingala the thickness was 0.80 metres. There were non-load bearing
partition walls as well meant for the purpose of dividing one room or
portion of a room from another. These walls were built with single bricks.
The width of the partition walls was 0.40 metres at Satanikota. The bricks
were laid in two stretchers followed by a header and thus the width of the
wall including its mortar came to be about 0.90 metres at Satanikota. The
walls formed into square and rectangular rooms, which varied in size from
4.0 x 4.0 metres to 12.0 x 17.0 metres. At Dhulikatta and Nagarjunakonda a
typical plan of what can be called as a chatussāla was noticed. It had four rectangular halls on the four cardinal directions with
a central open courtyard. A slight change in this plan has been seen at
Nagarjunakonda. Here a spacious square hall at the centre, had four
rooms on four corners and the entire structure was surrounded by a row of
five cells on all sides. The other buildings comprised of 1 or 2 rooms
with a narrow front, and a verandah. At the rear there was sufficient open
space which was perhaps left for the kitchens.

The richmens' houses at Nagarjunakonda were built of brick walls,
encased with Cuddapah slabs. This was a development, probably made as a
protective course to prevent the walls from dampening. After this, the
walls were plastered with lime. Inside the walls, chases were cut and
sometimes, postholes was noticed on the top of the walls as at
Polakonda, Dharanikota, Satanikota and Nagarjunakonda to receive the wooden frames of the roof. However, the load bearing brick
Wall can be seen as the most common form of building construction during this period.

Walls built of rubble or shale stones have also been reported for sites like Kyathur and Nagarjunakonda. At Kyathur, the structures were built of dressed laterite blocks of medium size mixed with cut shale stones and pebbles set in mud mortar [Plate III]. Rubble built houses with 2.0 metres thick wall have been recorded at Nagarjunakonda at site no. 13. The change of the medium for these constructions was due to its easy availability at the sites. The walls must have been built with the help of plumb-bobs which carry the perpendicular line to the required height. Terrocotta plumb-bobs have been recovered from the Eeleswaram excavations. Scaffolding was also necessary for making stone and brick walls. The walls of the houses of the rich and royal people were built to satisfy the functional requirements of stability, strength, durability. They were also more fire and weather resistant than the humbler dwellings which were prone to fire and other accidents and demanded periodical repairs, since they were built of perishable materials.

Mud mortar as a binding material was used to spread horizontally between the various layers of walls. For most of the walls of brick or stone, mud was invariably used as mortar. However, a solitary example of using lime mortar for the construction of a wall has come to light from Satanikota. The engineers had gradually become aware that the potential tensile strength of the individual units of brick work could be developed further by the forces induced or enhanced by a strong mortar at the horizontal bed joints. Hence, they used strong lime mortar at Satanikota. It has been rightly suggested that lime mortar, having the property of the
PLATE III

Period II: Brick walls of a rectangular house, Polakonda, Sub-region B

Period II: Rubble walls of a rectangular house, Kyathur, Sub-region A
ability to spread, and to retain water against the suction of brick, was a process that led to a significant development of bond with the brick and further it was resistant to cracking and rain penetration.

The roofs of the buildings also varied depending on the economic status of the people from simple thatched ones to tiled roofs and their slopes varied from being conical to flat roofs. In case of the houses of the poor, the roofs were invariably of vegetable material whereas, it differed in case of the houses of the rich where they were made of different types of tiles. The Amaravati panels provide us the evidence of different types of roofings. Huts in circular, rectangular and square plans had hemispherical, barrel vaulted and curvilinear roofs respectively as seen from the Kāvikumāra, Somanassa and Mattavindaka Jataka panels [Figure 4]. Huts with roofs of palm leaves, Pannasāla, domical in shape can also be seen from the sculptural panels at Nagarjunakonda and Goli. An attempt in copying a thatched roof in rock cut architecture can be seen at Mahabalipuram in Tamil Nadu during the 7th century A.D.

Different kinds of thatched patterns for roofing have been mentioned clearly in the early Buddhist works. The actual roof, cadana, was to be either thatched with leaves called panna, grass or reed called trna or covered with tiles, called qinjaka and also could be covered with skins. The cottages were said to be made partly of timber, darukutika, reeds, nalāgāra; straw, tīnāgāra, tīnakutika; leaves pannakutika. The roofs were also called Sudhāchadana covered by lime; Istakachadana covered by bricks and Śilāchadana covered by stone.
For thatched roofing, use of long wooden beams fixed to the posts was necessary. On these wooden beams, wooden planks must have been placed, as the spaces between the beams were generally very wide. Reed matting was then laid over the planks and covered with a layer of mud as a water proofing course. In case of conical and hemispherical roofs, the grass bundles were probably placed overlapping the earlier ones and then spread so as to drain out the rain water. This practice of making roofs can still be seen in most of the coastal areas of Andhradeśa. Some houses at Nagarjunakonda had flat slabbed roofs over wooden rafters with proper slope.

Buildings laid with terracotta tiles have also come to light from Dharanikota, in sub-region C, Satanikota in sub-region D, Peddabankur in sub-region A; and Nagarjunakonda in sub-region B. These tiles were double and triple grooved and sometimes, perforated. The tiles were rectangular on plan with rounded corners and a flat upper side. They had three or four channels in the form of grooves. On the undersurface the groove ran lengthwise for receiving the ridge of the adjacent tile. They were kept in position by driving nails into the holes at the breadthwise top into the wooden rafters of the roof. At Nagarjunakonda, the tiles were either fixed by inserting nails in the holes and fixing them into the wooden rafters covering the roof or, to tie them to the rafters with thread or copper wire. The tiles were made very finely, mixed with straw and some lustre was also given. After preparing them in moulds they were well-burnt in the kilns. The kilns of brick and tiles have been unearthed at the University area at the site of Nagarjunakonda.
During this period one can notice that there were no chronological stages in the building of different types of houses. Some buildings were built with sophisticated technology as they were multistoried dwellings and were necessarily provided with all the amenities as seen in the panel sculpture of Amaravati cited above and as indicated by the extant remains found at Nagarjunakonda. On the other hand, huts built of simple technology co-existed side-by-side with these sophisticated buildings. Only a few people in the society had access and control of resources to be able to afford the sophisticated technology.

The larger part of society had to employ simple technology for their dwellings using naturally and easily available building materials. Huts of different types have also been portrayed in the contemporary sculptured panels cited above. The archaeological evidence of postholes on the periphery of the huts attest that large numbers of huts were built to house the common people. In the beginning there were huts as noticed at Amaravati, whereas in the succeeding phase comparatively more developed dwellings have been reported from Satanikota, Veerapuram and Nagarjunakonda. Further, in the last phase, i.e., 3rd century A.D., huts are seen built on the debris of the earlier dwellings as seen at Polakonda and Dhusikatta denoting the urban decay at the end of this period.

The houses received light and air through the doors and windows. Windows of three kinds, viz., \textit{vedikāvatāvana}, \textit{jālavatāvana} and \textit{salākavatāvana} [Figure 4] are known to be from the sculptural representational panels of Amaravati and Nagarjunakonda. Providing other amenities which make life easier, also formed part of the planning that
went into improving the building technology of the period. Among the amenities, floorings, hearths, granaries, water supply and sanitary arrangements and roads are important to emphasize upon.

The floors were made up of rammed earth, lime plastered and concreted, brick and stone paved. Rammed mud floors have been noticed at Nagarjunakonda where gravel was laid to a depth of 2 to 4 inches thick and plastered with lime. Due to the short span of life of these type of floors, improvements have been seen in the flooring which were laid with brick or, were stone paved. Floors paved with brick have been reported from Peddabankur, Dhulikatta [Plate IV], Kondapur and Nagarjunakonda. Pebble floors have been noticed at Nagarjunakonda only. Stone paved floors have been seen at Satanikota and Nagarjunakonda. To meet long term performance requirement floors were laid with concrete. Lime concrete was laid as flooring at Dhulikatta. Thus we see that there was a gradual development in technology of laying the floors from the earlier simple rammed floors to the making of concrete floors.

Granaries to store food grains were built of bricks on well-laid foundations as seen at Satanikota and Dhulikatta [Plate V]. Partitioned granaries have been found at the latter site. They were built in an inverted funnel or pyramid shape with bricks in receding tiers. The roof was laid with tiles. At Satanikota nails and tiles were recovered by the side of the granaries [Chart I B.14].

The architecture and technologists of the period took care to see that a good water supply system and sanitary arrangements were made inside the
Period II: A brick house with partition walls, Dhulikatta, Sub-region A

Period II: Brick floor of a house, Dhulikatta, Sub-region A
Period II: A brick granary, Dhulikatta, *Sub-region A*
houses. To get clean and healthy water, the people dug wells into the ground. This is an innovation of the period whereas people in Period I purely depended on the natural water sources. To avoid seepage and contamination of the habitation surface, the foundation of these wells was taken right into the virgin soils. In order to make them round at the opening, wedge shaped bricks were used. As mentioned earlier, drawing water from below ground level was an innovation of the people of Period II. Habitations situated on the river banks had naturally used river waters, whereas the habitations away from natural water resources could not depend upon the ground water. The technology of digging well was very significant for early historic society and therefore, even though some of these habitations were situated by the side of the rivers, water for domestic consumption was derived mainly from the wells dug nearby. Wells were sunk into the ground, cased with wedge shaped bricks and sometimes, lined with terracotta rings. Every dwelling had its own well. Wells of big size meant for public uses were also dug. They were provided with steps to access the water. Pavements in brick were made all around the wells. Every care was taken to prevent seepage of water and the sagging down of the foundations. The wells dug into the ground for drawing water have been brought to light in large numbers at **Kotilingala**, **Dhulikatta**, **Peddabankur** and **Nagarjunakonda** [Chart I B].

The wells at Kotilingala, Peddabankur and Dhulikatta were built of wedge shaped bricks [Plate VI]. At Dhulikatta, a brick well square in plan was exposed. Adjacent to the well was a platform with two **postholes** evidently for erecting wooden posts to support a **pully**. Water was drawn by means of a rope tied to a pot or metallic vessel. A unique illustration of
Period II: A circular well with wedge shaped bricks, Peddabankur, Sub-region A

Period II: A well with terracotta rings, Majeru, Sub-region C
a brick built well is found represented on a Gandhara sculptural panel, which shows a girl drawing water from the well, by a rope keeping her legs in characteristic pose. An improvement in the technology of building the wells has been noticed at Peddabankur, where a well dug to a depth of 4.10 metres was lined with terracotta rings. Wells lined with terracotta rings have also been reported from Majeru [Plate VI] in sub-region C. Though this cannot be a superior technique to lining it with bricks, but it is cheaper than the latter economically. The rings were of convex body, 76 cms. in diametre, 38 cms. high and 25 cms. thick. Altogether 21 rings were used from top to the level of the morrum bed. The earthen strata was cased with rings because there was every possibility of collapse of the walls. These rings went up to hard soil, i.e., to the morrum levels. To ensure safety, the top most course of the terracotta ring well was lined with square bricks. Often the top course of the parapet wall of the well was built with coping stones. This arrangement also reveals their thorough observation in using the wells. These coping bricks facilitated them in preventing the entry of rain water. Hard morrum was rammed all around the well.

The process of excavating the wells around the houses can be explained thus. After the construction of the house was over or when it was in final stages of completion, a suitable place in the compound for digging a well was selected on the advice of the water diviners or with the knowledge of the inhabitants about the local water table. Then a set of three or four persons might have been put to work on the job of digging the well with crowbars, spades and baskets. The earth was dug out and lifted from the well, while digging was in progress and the process continued till the
water level was met. The mouth of the well was narrowed with a projection of sufficient width to encase it with bricks. The people were able to prepare wedge shaped bricks, which were best suited in order to get a circular shape. The knowledge of making pottery enabled people to design, and prepare burnt circular earthen rings. The gap between the bricks or rings and the earthen wall was filled with compact earth and rammed. The top portion of the wells was built with parapets as a safety measure. Finally, wooden posts were erected on one side of the well so as to fix a pulley, facilitating the drawing of water by means of a rope and a bucket.

At Kotilingala near the wells, platforms, cisterns or tubes and bathrooms were built in brick [Plate VII]. Open or concealed drains were also built near the wells, to carry the used water away as at Peddabankur. At Nagarjunakonda, circular, square and rectangular wells were built with stones. The above descriptions of wells lead us to conclude that the people of Period II were careful to consume hygienic water for drinking purposes and therefore, took great care in seeing that no seepage was allowed into the wells. Well making technology was mastered during this period and remained the same up to the 5th century A.D. barring minor changes. Water cisterns and tanks near the residential areas is being discussed in the next section of this Chapter on Irrigation Structures.

Another important aspect of the building technology in the habitational area during this period was the sanitary arrangement that was laid out. The objective was to provide the occupants of the buildings with a safe and healthy environment. The increase in the number of houses in
Period II: Brick wells and cisterns, Kotilingala, Sub-region A

Period II: A soak-pit with terracotta rings, Peddabankur, Sub-region A
many of these urban centres infact demanded that attention be given to the standardisation of hygiene. Thus, drains to carry dirty water away from the living areas were devised. In the early phase of Period II open drains were built as seen at Amaravati databale to about the 3rd century B.C. Since it was observed by the people that uncovered and open drains were unhygienic, they gradually began to build drains which were covered either with brick or stone. These coverings could be removed at anytime in case there was an obstruction in the flow. Drains were also connected to soakage pits as noticed at Peddabankur. Drains inside the houses were often connected to soakage pits. At Dhulikatta was found one such drainage channel which was connected to a soakage pit and it was partitioned into two. Since the earthen canals often collapsed, they were projected by brick constructions. At Peddabankur, a deep pit was cut into the level natural morrum to a depth of 1.90 metres. Here, another drain was connected to a soakpit lined with terracotta rings [Plate VII]. This arrangement reveals that the people had taken utmost care not to allow the drainage to enter into the subsoil as this would spoil the surrounding area.

Drains attached to houses, bathrooms, wells or enclosures have been noticed at Dharanikota, Amaravati in sub-region C, at Kotilingala and Peddabankur in sub-region A and at Nagarjunakonda in sub-region B. The drains connected to soakage pits have been noticed at Peddabankur where a covered drain built in brick was found to a length of 13.30 metres. The side walls had three courses. The bottom ones were paved with brick and covered by a single course of brick. Side vents were provided at varying intervals of 1.70, 2.20 and 2.90 metres to allow excess water to overflow.
It was finally connected to a deep pit. A huge drain connected by small drains has also been noticed at Nagarjunakonda. This was probably the main sewer drain of the city. A drain or sewer which led out of the city has been mentioned in the jātakas as niddhamanāmaṃga. An enclosure wall at the same site was provided with many outlets of 2'-0 wide and 7" depth at different places, probably to provide a flow for the rain water.

Workshops of blacksmiths, sculptors, potters, bangle and bead makers have been reported from Dhulikatta, Kondapur and Nagarjunakonda. An interesting feature was noticed at Kondapur where a house consisting of an underground chamber ranging in depth from 1.52 to 7.62 metres was found and identified as a workshop area. Occurrence of beads in different shapes and sizes, coin moulds and iron furnace with platform and cisterns reveal that these underground chambers can be considered as some sort of workshop. At Nagarjunakonda, workshops of goldsmiths, ironsmiths, potters and sculptors attached to residential quarters have been brought to light. Availability of moulds of gold jewellery, iron furnace, water cisterns and terracotta pipelines, potters kiln and a good number sculpture showing different stages of carving denote that these were workshop areas which were mostly built in stone.

A hallmark of the building technology of the period was that habitation areas had enclosure walls to provide safety and security. Enclosure walls, rectangular on plan were noticed at Dhulikatta, Peddabankur, Veerapuram and Nagarjunakonda [Chart IIB]. The thickness of the brick walls varied from 0.65 metres to 2.00 metres and they were raised on rubble foundations. At Veerapuram and Nagarjunakonda, enclosures were
built in stone and this can be seen as a development in building construction. It is more difficult to build stone walls since the quarried rough stones need to be dressed evenly to suit the plumbline, whereas construction of compound walls with brick was easier because of their premoulded regular shapes. Construction of compound walls has been mentioned in the iatakas and can also be seen in sculptured panels at Amaravati and Nagarjunakonda.

An important aspect of the building technology of Period I was the construction of large public utility structures such as amphitheatres, common baths, resthouses and roads. The amphitheatre and stadium at Nagarjunakonda are an indication of the ability of the people during this period to undertake large scale monumental constructions which were not religious in nature. Both engineering skills and financial support were needed for this. These buildings were built mainly for the leisure pursuits of the elite in society. An oblong stadium with a central arena datable to the 3rd century A.D. was a massive building measuring 300'-0 x 259'-0 in length and width and 15'-0 deep. All around the inner side of the stadium, brick was used with a flight of steps of 2'-0 width. A pavilion was built on its western side. Plain platforms were constructed on all the four sides. Corridors were also provided in the stadium. The central arena was levelled up and kept free from pebbles. Another stadium rectangular in plan, was found with flights of steps on three sides and an entrance on the fourth side. Scholars like K.Krishna Murthy opine that the location of this stadium on the hill slopes and the gallery arrangement speaks of the sound knowledge of the builders in acoustics. The necessity of spacious walls and arena for performing sports activity have been mentioned in the early literature as kṣilāgriha.
To execute such buildings it was necessary for the architects to have a pre-conceived plan and first and foremost select a suitable site. Then a big trench was excavated according to the design, and steps were built with landings from the bottom to top in ascending manner. The gaps were duly filled with earth and dressed waste. The flooring and steps were systematically executed so as not to allow their collapse due to erosion.

The excavations at Nagarjunakonda have also brought to light a pillared pavillion attached with a green room. These two structures were enclosed by a compound wall. Rest houses known as viśsamanaśāla or punvasāla were also built at the same time to facilitate the accommodation of the public, visiting Nagarjunakonda which was a significant centre of Buddhist learning. They were built with lime stone pillars and slabbed plain roofs and floors. Keeping in view the fact that the public would be frequently visiting the place, the architects with foresight had the floors made with a mixture of pebble and concrete, over which a smooth plastering was then done. This would prevent their constant repair and maintenance and thereby save finances.

Ghats or bathing places were built with beautifully arranged flights of steps, for easy access and for the use of all the people to take baths on ceremonial occasions. These are prominently in evidence at Nagarjunakonda and Eeleswaram, both sites being situated on either bank of the river Krishna. Recently one more bathing ghat has been brought to light at Chandavaram in sub-region B [Chart IB]. Besides, a common bath
built with a well paved platform, water tank, steps and water tub have also been found inside the habitation. Construction of massive structures provided with steps and landings, facilitated the public at large to take baths even when water level in the river fluctuated in some seasons. This is a significant feature in building technology of the period in which the knowledge of the masons was put into practice, in securing the banks with steps especially since they were constantly being washed by the water of the river.

Roads became important to lay out with development of different types of transport during the period. Well-laid and made up surfaces of the roads have been noticed at Dhulikatta, Satanikota and Nagarjunakonda. At the last mentioned site, there were five roads parallel to each other running between the river Krishna and Phirangimotu on the east. Roads were flanked by rubble stones on either side to withstand the lateral thrust produced by the heavy traffic. Side lanes or byeroads were also provided for. These lanes connected the habitational area to the religious and public utility buildings. Unfortunately, hardly any excavation report contains detailed information on how these roads were laid. Literary references of the period mention main streets as rājāmāgga, mahāpatha, tōranamāgga, ordinary streets, as veedhi and by-lanes, as an̄tharveedhi. For laying roads the intended paths were first levelled. Then boulders and pebbles were picked up and finally, they were paved with hard morrum to withstand the wheeled transport.

The above information on building technology of the habitation structures and public utility related structures, reveals that two types of building technologies co-existed side-by-side, viz., simple and
sophisticated, to suit the needs of both the common and rich people respectively. The archaeological data, literary texts and sculptural panels provide us enough information that the common people had circular houses of wattle and daub covered with thatched roofs whereas, the middle class and rich people had square and rectangular houses built with brick or stone walls and covered with slabs and tiled roofings.

The royal palaces were usually multistored with flat roofs having balconies, windows, staircases, doorways and enclosure walls. Workshops were provided with all the necessary appendages such as working platforms, water cisterns and furnaces. The residential quarters were built in both brick and stone and enclosed by compound walls. Workshops were public utility structures primarily limited to use by the artisan and merchant classes, who generally were part of the urban elites. Regarding water supply and sanitary arrangements, every housing unit had its own system of dug out wells built with brick or lined with terracotta rings and drainage canals which were also lined and covered by brick. They were appropriately connected to ordinary soakage pits which were sometimes lined with terracotta rings. To enjoy the leisure pursuits, public utility structures such as the amphitheatre, stadium and public baths/ghats and resthouses were built, with permanent building materials. The earthen rammed floors from the earlier period were improved with the use of lime concrete and were also paved with both brick and stone.

The evolution of building technology in this period can thus be summarised in the following manner. The wattle and daub walls of the simple dwelling structures were perfected with a better technology by
erecting mud walls and this was then followed by the use of the medium of brick and stone for construction. This offered a better stability to the dwelling structures and a longer duration of their existence. The roofs at the beginning of Period II were thatched ones but over a period of time they too changed and soon brick, stone and tiles became more popular modes of roofing. The former however, continued to exist side-by-side. Tiles, grooved and perforated were manufactured and used for roofings and were fixed to the wooden frames. The technology of brick making was perfected and innovated upon during the period. They were well-burnt and moulded ones in rectangular shape. Wedge shaped bricks to suit the circular periphery of the wells were manufactured for the first time. Brick and stone walls were raised on well-laid foundations, below a ground level according to the nature of soil. Some structures were directly raised on the bed rock. Brick and stone walls were invariably built with mud mortar while lime mortar was used mainly for plastering the walls and floorings.

Upto the 3rd century A.D., the structures were built with brick walls only. However, from the second half of the same century we witness an improvement in technology as the brick walls were strengthened by encasing them with stone slabs. This added a significant amount of stability to the structures and prevented the dampening of the building through the entry of rain water. Houses were provided with front verandahs and partitioned walls, built by a single brick course inside the houses. This reveals the economic aspect of the building technology. Since the partitioned walls were not load bearing components, the architects used only a single course of bricks in order to divide the halls into separate cells. As a safety measure, the houses were enclosed by compound walls. Walk away pathways laid in traditional manner were perfected and improved.
with well-laid roadways connected to sublanes.

It can further be said that the role of the architects in building technology had been to design buildings that reflected the interests of the public. They became the meeting point between the society and technology. The architects in their enterprises had to have a sound knowledge of the soil mechanics, topography and location, before building the structures. Planning and designing of all types of buildings revealed their organisation of space for different purposes, according to different rules that reflected the needs, values and desires of the people. The architect had to coordinate with other consultants, experts and craftsmen in different fields of building technology. However, he controlled the different aspects of the design and the structural process of arranging for lighting, water supply, sanitation and even acoustics.

Period II thus witnessed important developments in building technology. The evidence for habitation buildings and public utility structures for this period is substantial and enables us to conclude that it reached a watermark by the end of this period in Andhradesa. After this period such information is rare to come by. Some of the above delineated descriptions of ordinary housing patterns and material used to build them are valuable since these traditions continue even today in rural areas. Material evidence of the survival of such techniques in archaeology thus enables us to evaluate their time tested efficacy which the collective experience and knowledge of the people had preserved.

Information on habitation and public utility buildings of Period III
and IV is scanty and not forthcoming, because the sites that have been tapped for archaeological excavations have been very few. In this regard it must be mentioned that only future excavations may provide evidence of ordinary housing patterns and public utility structures for Period III. This absence has, at present also to be understood against the background of the debate that is raging among scholars on the nature of urban decline and growth from the early medieval that we have outlined above in Chapter I. Some scholars suggest that urban decay was caused by decline in both internal and external, and the collapse of stable empires and religion. These factors had in the earlier period generated finances which was mainly responsible for the existence of different types of building structures that had been concommitant and prolific with early historic urbanisation.

Despite this general absence, a few sites in Andhradesa have yielded data on habitation buildings and these are discussed below. Excavations conducted at Keesaragutta [Chart I C & I D] in sub-region A have brought to light a complex of residential buildings [Plate VIII] in Trisāla Vasthu pattern, belonging to the 4th-5th centuries A.D. All these structures have been enclosed by a massive wall. Among these, there was a huge brick structure containing five cells prefaced by a common verandah which was provided with a square portico in front and a flight of steps to approach it. Considering the width of the wall, it is likely that this must have been a storeed building. The flat roof might have been covered with terracotta tiles and plastered with lime. It was supported by wooden posts as is indicated by the presence of post-holes. The bricks used measured 46x23x7 cms. Another three celled structure here has also been identified, with a portico and a flight of steps, which ended with a
moonstone. The exterior surfaces of the walls were finely plastered with lime. Some houses at this site had rubble basements. The partition walls measured 0.75 metres in thickness. The flooring was brick paved. The excavations conducted in the contiguous region at the site Paunar in the Wardha district of Maharashtra, have also laid bare brick structures, tiles and ring wells, for soakage and well-built houses with excellent foundations belonging to 4th-5th centuries A.D. Amita Ray's study on the 'Urbanisation in Bengal' reveals that from the sixth century A.D. onwards cities grew up in Bengal, with a recognizable urban character, backed by the growth in socioeconomic aspects which accelerated the development in the agrarian base. In this connection she cites two archaeological sites, viz., Pundranagar and Kotivarsha, both of which were fortified and had palace and religious establishments. Keesaragutta is thus one such site of the Period which did not decline as other centres did after the third century A.D.

The above information leads us to conclude that the building technology of Period II was more or less continued into Period III but empirical evidence for this at the moment is limited only in sub-region A from the above mentioned site at Keesaragutta. However, information on habitational and public utility related structures such as dwellings, mathās and hospitals attached to the temples can be described from a few excavations conducted in Andhra Pradesh at some temple sites. Contemporary literature and epigraphical sources have also been used to construct a picture of such habitational structures.

At Alampur in sub-region A, a habitational deposit was noticed by us
Unfortunately, excavations have not been conducted at this early medieval temple town. While dismantling some temples datable to 7th-8th centuries A.D. which were located on the left bank of Tungabadhra river that were threatened by submergence due to the building of Srisailam dam, I observed a deposit of 1.00 metre thick occupation. This layer was of pāṭī earth mixed with stone and brick bats and abundant pottery pieces resembling examples of the Vishnukundin Period [Chart I C & I D]. Here again, unless fullfledged excavations are done, the true nature of urban settlement in this temple-town will not be possible to delineate. In another case, ruins of early medieval habitation in the shape of fortifications, foundations of residential buildings are still seen at Mukhalingalm. However, because of the modern houses that have arisen over the debris of the above ruins, details are not clearly available regarding the nature of these settlements either. In fact, it would not be an exaggeration to say that most of the early medieval town settlements have been superimposed by subsequent habitations and therefore, have been difficult to excavate. A similar evidence comes from sub-region C at Asanapura, identified as Achalapura, near Yallamanchili in Visakhapatnam district. This has also yielded huge quantities of potshreds and pāṭī earth. Both these pieces of evidence testify to the fact that this town was in existence from the 7th century A.D. onwards. K.Suryanarayana suggests it might have been burnt down by the Eastern Ganga Kings during their invasions. A 7th century inscription of the King Jayasimha-I mentions that he made provision for a dwelling place in Kudivada near Asanapura and this proves beyond doubt that there were dwellings here before its decay.

Therefore, since the empirical evidence from archaeology on habitation
buildings is very poor, we can draw upon the contemporary literary works, for India as whole regarding the descriptions of various types of buildings and the possible technology used to build them. The *Amarakośa* furnishes us information on towns and houses. The *Puranas* compiled mostly during the early centuries of Christian era and some during the early medieval Period (600-1200 A.D.), deal at length with the subject of building houses. The *Matsyapurāṇa* in its Chapters 259 and 260 deals with the descriptions of buildings and their components such as plans, measurements, classification of pavillions, halls, etc. Building materials have also been described in Chapter 257 of the same work. The *Brhatsamhitā*, a text of the 6th century A.D., has descriptions on *Vāstuvidya*, where some rules have been prescribed for the selection of a site for the proposed building. It is stated that the site was to be soft, even and of sweet odour and taste. It was, on the other hand, not to be hollow from inside. Further, it was good if it abounded in commendable herbs, trees and ores. It also prescribes varying sizes of houses for the different grades of ruling Chiefs and also for members of the four *varnas*. Some of the houses are described as single storeed while the majority are noted as *multistoreed* and this, therefore, implies that a sound technology was available to the architects and builders of such big houses. It can thus generally be suggested that house structures of the Period III were mainly *multicelled* and storeed buildings with front verandahs and built in brick. Floors were rammed and roofs supported by wooden frames and posts supporting the walls. The walls were plastered with lime mortar. The entrances were approached by flights of steps.

For Andhradesa there are inscriptive and literary references which
describe public utility buildings such as maṭhās, hospitals and alchemical laboratories. The inscriptions from Alampur describe some of these in detail. Maṭhās are monastic establishments, separate from the temple, specially built for the residence of religious teachers, who had to impart education. Mathas also served as feeding houses for the students, ascetics and pilgrims. In this connection, the existence of a Saiva matha at Talamanchi in Nellore district which falls in sub-region C, dated to the 7th century A.D., can be cited from the inscription of Chalukya Vikramāditya, wherein he donated some land to his preceptor Sri Meghāchārya for the said purpose.

Another interesting information regarding public utility constructions of the early medieval period is the mention of rasāśāla, i.e., a chemical laboratory which is found at Alampur [Chart I C & I D]. According to I.Sanjiva Rao, the rasāśāla at Alampur was built in accordance with the rules laid down in rasasastra. It is said that metallurgical operations requiring the use of fire, were to be taken up on the south-east quarter, grinding operation on the southern quarter, surgical operations on the south-western quarter, washing operation on the western side, drying up operations on north-western side and finally, alchemical operations were to be taken up on the north-east side. The storage of the raw materials was said to be done in the centre. This description tallies exactly with what has been found in the form of the roandapa-like, closed stone building situated on the northern side of the temple at Alampur. At present these structures serve as a Museum. The above literary citation on the construction of the said building pertaining to information on industrial and technical activities is a rare piece of evidence and one of its kind.
The period from the 10th to the 13th centuries A.D. provides the institutional framework for great agrarian expansion and urban growth in the succeeding centuries. However, many scholars have attributed this period with enough economic expansion for rural settlements to be transformed into semi-urban or fullfledged urban settlements. The former grew around Brahmadeyas which were prominently brahmin habitation areas. Revenue from these lands were often offered for the maintenance of the educational institutions and temples. Thus, it is argued in the context of Tamil Nadu, that during this period, due to the developing trade between the town and country, villages which earlier were centres of fairs and markets, now came to be developed as towns. In the context of Andhradesa the Basinikonda epigraph from sub-region D dated to 1050 A.D., states that an assembly of merchants converted the village Siravalli into a town, Pattana. The same inscription mentions it as an erivirapattana or an inland port and as an important trade centre, so much so that it came to be provided with armed protection. Continuity of settlement and the growing prosperity of villages in some regions of Andhradesa has been observed from several epigraphs of the period which speak of urban influence in sub-region D. Another inscription dated to 1187 A.D. records that a number of gavundas (village headmen) who came from nagarisma (the border of town) with their carts, settled in several rural settlements.

Thus, during Period IV, the study of habitation structures is clearly related to the revival of towns and cities, as found mentioned in the contemporary literature and epigraphs of the 11th to 13th centuries A.D. It has been observed that there was brisk trading activity, and as a result, some coastal port towns such as Kulottunga Chōdapaṭṭana, identified
with modern Visakhapatnam, Cholapāṇḍyapuram, i.e., present Ghantasala and
Desivuyakonda paṭṭana identified with Motupalli, all situated in sub-region C, rose to prominence. Many inscriptions from Mukhalingam, datable between the 8th to the 11th centuries A.D., mention towns and cities such as Simhapura, Dantapura, Draksarama, Dirghasi, Vengi, Vijayapuri, Bhogapuram and Dharmapuram. Further, a text of the 11th century A.D., the Manasollāsa, enumerates important early medieval Andhra urban centres with textile industries located at Podanapura, present day Bodhan, Chirapalli, present day Chirala, and Allikakula, modern Srikakulam. Instances of towns founded by Kings and minsters are also numerous from inscriptions. Jagadala Mummadi, the younger brother of Ganapatideva, claimed to have constructed a town on the banks of a charming lake called Ganapapura in 1245 A.D. All these towns mentioned in inscriptions have to be understood against the background of the re-development of the market economy of towns from the beginning of the 11th century A.D. in many parts of south India. It has further been pointed out that this coincided with a recognizable increase in the circulation of metallic money as indicated by money payments for constructional labour. Regarding the evidence of coined money and its re-emergence in medieval Andhradesa, information can be gleaned from literary, epigraphic and archaeological sources. This kind of urban activity was conducive for the growth of habitation and public utility buildings. However, most late medieval townships remain under continuous occupation. This makes excavation work exceedingly difficult and therefore, there is a dearth of information on such constructions which were a necessity for every day use. Only if these townships had got deserted, as in the case of Hampi, that archaeological information would be available in a substantive and rich manner.

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Within Period IV the Kakatiya phase of rule saw a very prosperous regime emerge in medieval Andhradesa. People could exercise power through their assemblies which was more than that exercised by the māndalikas. The village assemblies were called as a aseshapraia, samasthapraia and occasionally as astādaśapraia. Of all these local bodies, a bigger committee called sthalasamava representing all the people of the sthala or group of villages has been importantly mentioned in the epigraphs of the Period. The strong local economy is indicated in one instance by the fact that to donate land to some temples, the early Chiefs of the dynasty had to obtain permission of the village gavundas, the village heads of Sanigaram and Bezavanka, a place situated in sub-region A. Likewise, the māndalikas sought permission of the village assemblies to donate lands and to collect additional dues, as recorded in an inscription found at Taduvai which is located in sub-region B.

This background enables us to describe, based on both literary and epigraphical sources, some of the habitational and public utility buildings for the latter half of Period IV such as dwelling places, mathās, satrās, colleges, hospitals roads and highways. There is only a solitary example from an archaeological source that reports public utility buildings from the excavations conducted at Motupalli in sub-region C [Map V]. Inscriptions provide us the terminology used, to refer to buildings and the donations of house sites, called niveśana sthala, to various groups. Literature on the other hand, offers information on the different types of buildings of the period. An epigraph from Sanigaram of 1052 A.D. refers to a donation of 12 house sites. The inscription found at Sirur in sub-
region A informs that a mahāsāmanta called Aggalayya made a gift of land, garden and a house to one Siddhantadeva. The Nagulapadu inscription dated to 1303 A.D. refers to a gift of some land for house sites, sthana nivesana. The thousand pillared temple inscription of Hanumakonda dated to 1163 A.D. refers to the fact that Brahmins were living in bhavanas, i.e., storeed buildings. Some inscriptions also provide information on the layouts of market centres and cities. At Peruru, a market town in sub-region B, there were separate quarters, i.e., residential buildings for the brahmins, the Telugu and Arava merchants, Gollakāmpulu, Telikis, and local officials. At Nellore, known as Vikramasimhapuri, the capital of the Telugu Chodas there were constructed many quarters belonging to the Brahmins, merchants, artisans, cultivators, weavers, and others.

The Ganapesvaram inscription of Ganapatideva mentions that the different localities of the city were built and developed by Rudra and were named after the Chief towns of the centres he had conquered such as Panugantivada, etc. Further, it states that he peopled these newly developed colonies or satellite towns with the inhabitants of these respective towns conquered thus, making the capital city truly metropolitan and cosmopolitan in nature. An inscription found at Hanumakonda dated to 1170 A.D. refers to the fact that King Rudra burnt the pura of Medarāja. From this, it is possible to infer that the houses in the capital town were probably built with perishable materials, such as thatched roofings and wooden frames which must have burnt easily. The Mogulutla inscription of the 13th century refers to Warangal city with saudhas and harmyas, i.e., buildings built by lime mortar and refers to them as storeed ones. The Bayyaram Tank inscription datable to the 13th century A.D. refers to the fact that Mailama built three new towns, viz., Mahadevapura, Bayyaram, and
Dharmavaram, and in the last mentioned one she is also said to have built public utility constructions such as hospitals and rest houses (viśramanaśālas).

The Chebrolu inscription of Jayapa Senani, the Commander-in-Chief of Ganapatideva, mentions that after the defeat by Jayapa, the vilāsa harmyas, the luxurious storeed buildings of the Kings, were found ruined and were seen with grass grown on their terraces. In the descriptions of a 13th century inscription called as the Niroṣṭhyakāvya, found incised on Ursgutta near Hanumakonda, there are a few references to contemporary buildings such as a storeed building with bed rooms. The same inscription also mentions that the whole of Andhradesa of that period had countless cities which outshone the numerous divine cities. It further goes on to elaborate, with some exaggeration, that the assemblage of numerous damsels with moon like faces, on the top most floor of the houses in the city made it difficult to see the existence of the real moon in the sky. These inscriptional references to cities and the habitation and public utility buildings are corroborated by descriptions in an important text of the period called Krīdābhīrāma. This work portrays the contemporary life of Warangal city with all its details and glory during the first quarter of the 14th century A.D. The text mentions important trade centres like Madisanta, Mailasanta, Akkalawāda, some roads and storeed buildings and also hutments. It describes a painting hall of Machaldevi, where paintings of Paināticharitra were done, on the smooth surface of the walls which were plastered with fine lime. It further informs us that the Warangal city had 300 large and small commercial establishments and shops.
The archaeological sources for Period IV are few but fortunately we have structural remains of some unique buildings identified as a customs house from the site of Motupalli [Chart I CS I D]. This was a famous port town during the medieval times and excavations were conducted here during the 1971-72 season. These excavations have revealed a huge brick structure, rectangular in plan, constructed of burnt brick in mud-mortar and plastered with lime [Plate VIII]. The thickness of the wall noted was 50 centimetres, the total length of the building measured 22.20 metres with a width of 5.31 metres. The height of the extant walls was 3.0 metres on the south-western side. All the four walls had off-sets, slightly above the floor level. Four doorways facing each other of the size of 1.07 metres broad, were noticed in the middle of the walls. Long iron hinges of door leaves were also found. Inside the building were two rows of pedestals constructed of brick and lime and provided with rectangular sockets, each with a depth of 20 cms. Wooden pillars might have been kept over these pedestals for supporting the roof which was covered with channelled tiles. A small stack of tiles was found at the floor level, outside the building which measured 24x13x8 centimetres. The site has also yielded Chola coins of Rājarāja and Chinese coins of the early Ming period. The above structural remains give us some idea on public utility buildings and building materials of the medieval period in Andhradesa.

There was no continuous habitation at this site, though it was the rain gullies which were responsible for bringing the remains to light. Initial explorations conducted at this medieval port town further led to systematic excavations. On the other hand, medieval settlements such as at Warangal, Alampur, Vengi, Visakhapatnam, Ghantasala, Hemavati, Kanduru and Vardhamanapuram have been occupied continuously. Therefore, the type and
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<th>S.No</th>
<th>Name of the Site</th>
<th>Sub-region</th>
<th>Type of House Plan</th>
<th>Foundations/Floors</th>
<th>Post-holes</th>
<th>Walls</th>
<th>Roofs</th>
<th>Associated Structures</th>
<th>Public Utility Structures</th>
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<td>1.</td>
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Key:
- Pit-dwelling
- Circular, Semi circular, Oblong
- Plastered
- Square
- Rectangular
- Mud
- Concrete
- Brick
- Plastered
- Stone
- Thatch
- Thatched
- Tile
- Platform
- Drainage
- Well
- Pathway
- Workshop
- Granary
- Wharf
- Amphiatre
- Stadium
- Matha
- Chemical Laboratory
- Hospital
- Customs House
- Satra
Period III: Rectangular brick house with verandah, Keesaragutta, Sub-region A

Period IV: Brick walls with lime plaster, Customs House, Motupalli, Sub-region C
exact nature of settlement of the period is difficult to discern because of later day *superimpositions*.

Further, on the above mentioned archaeological remains found at Motupalli it can be assessed that the plan of the building and building materials used were similar to those of the buildings in the early historic period. Despite the lack of systematic medieval archaeology the buildings of a public utility are often found attached to extant temples such as *mathās*, *satras*, colleges, hospitals and roads. As we shall examine in a subsequent chapter, temple building activity in Period IV was quite prolific and therefore, such constructions that come as appendages to the temple structures are also found in good number. The most common was the *matha* which played a prominent role in serving as a seat of learning and place of living for the priests and their young students. The Eastern Chalukyan King Amma II granted a village called Tadikonda in 954 A.D. to a Saivite *matha* designated as a separate dwelling place for monks at Bezewada which was said to have been a three storeed building decorated with pictures and paintings. Ruins of *mathas* built in stone during the 11th-12th centuries A.D. can still we seen at Jalalpuram, Kannekallu, Amarabad, Mallesvaram, Omkareswaram, Udmilla, Laxmanapuram, Velur and Kaluvakolanu. There is an inscription which describes that one Visvesvara Sivacharya the Rajaguru of Ganapatideva, is said to have established *mathās* at Kalesvaram, Ponnuaguru, Mantrakuta, Chandravalli, Nandapur, Komururu, Elesvaramu, Nivritthi Sangamesvaramu and Uttara Somasila. Branches of *Golakī* matha also established by Visvesvara Sivāchārya were set up at places like Malkapuram, Srisailam, Tadikalapudi and Tripuratankam. Vaishnavites too had *mathas* and one such is
mentioned to have been located at Simhachalam. An epigraph from Pushpagiri dated to 1300 A.D. mentions panchamathas.

Generally, as seen at Mallesvaram and Ramathirtham, situated in sub-region A, the mathās were built in stone and were rectangular on plan with a hall on the front side and an ante-chamber at the rear. The religious teacher might have lived in these chambers, whereas the front open hall, closed on three sides, was used as a place of learning and recitation of scriptures by the young students. These mathās as observed at the above two sites, were raised on randum rubble, flat foundations of red sandstone. The stones were joined very closely and their top portions were clamped with iron dowels. These might have been erected by using scaffolding materials as was done for the temple building. Above the walls, the roof was laid with long stone slabs fitted very closely, over which a concrete mixture of lime, stone chips and river rolled pebbles was laid as a water proof course. The floors were laid with neatly dressed slabs. The above information leads us to infer that the building technology of the public utility buildings such as mathās was not essentially different from that used in building temples.

Feeding houses called satras where food was arranged free of cost for saints, students and public on pilgrimage were similarly attached to temples, and likewise, built in stone during Period IV. In this regard we have ample references to them in the epigraphs of the period. satras as appendages to the temples utilised for public purposes have been mentioned in the inscriptions found at Vemulawada, Agasthyesvaram (Malleswaram), Draksharama, Pillalamarri, Peddagarlapadu,
A Simhachalam temple inscription dated to 1291 A.D. mentions that the commander of Narasimhadeva, the eastern Ganga King, established a college to provide instructions to the students. Hospitals were also set up as appendages to the temples. The Saidapur and Malkapur inscriptions give information regarding hospitals established at a Jaina basadi and at a Saivite matha, respectively. The Draksharama inscription informs us of the existence of a medical and health centre attached to a local temple. It was also mentioned that a certain Vaidya Suryadeva Pandita and Annaya Vaidyendra, visited this place and made some donations. An inscription from Mandaram registers a gift of two villages by Ganapatideva to Visvesvara Sivacharya who founded a matha, a college, a choultry a maternity hospital and a general hospital. The above references prove the existence of these important structures meant for public utility which were mostly built of stone because of the permanance of the material. Being attached to primarily religious monumental buildings they have survived intact in contrast to ordinary dwellings which were most probably made of perishable materials like mud, reed, tiles and hay.

Roadways and highways which form part of our discussion on public utility structures, and which facilitated land transport, are found commonly mentioned in the inscriptions of the period. An epigraph from Bodhan of 1056 A.D. mentions different streets of the town as Indranarayana veedhi, Brahmapuri veedhi, artisans' streets and the street of the dancing girls. A 13th century A.D. literary work called the Andhra Bhashabhushanam of Ketana speaks of a highway connecting the northern region from Ayodhya to Kanchi, running through Warangal and Nellore. There
were also routes from Motupalli to Karnataka through Yanamadala, Vinukonda, Tripurantakam, Panyam, Alampur and Raichur. As there was nothing mentioned about the materials used for laying roads we can not assess the level of building technology in relation to road building activity during this period as was done by us for the early historic period.

In an overview, the evolution of building technology of the habitational and public utility structures, i.e., buildings used by individuals or by a community for dwelling or other purposes of communal life, can be assessed from Period I to Period IV in the following manner. During prehistoric times, men had lived in natural caves or caverns. However, his movements to the plains in search of food during the course of his evolution and made him build semipermanent habitations with locally available materials. Natural rock shelters however, continued to be occupied for dwelling purposes. In Andhradesa, during the early phase of neolithic stage we noted interesting constructions for dwellings. These were pits cut into the ground. During the later phase of the same Period, rectangular houses with thatched roofings supported by wooden posts came into existence. During the last phase of Period I, i.e., the Megalithic stage, iron was introduced and people started building their houses with non-perishable materials such as stones. The houses of the neolithic and megalithic stages were circular, square or rectangular in shape. Floors were rammed with earth or morrum, some times, plastered with lime on stone chips. Walls were built of mud, wattle and daub. Hearths and fire places were built inside the houses. The prolific use of stone that could be quarried by use of iron enabled floors to be paved with shale stones. Compared to the rammed floors of the earlier period this was a
significant development in the evolutionary process of making good floors.

The associated structures or appendages to the habitation for Period I included cattle pens and refuge pits which were made with a rather simple technology at this stage. We find only one evidence of a pathway which represents the public utility structure of Period I. This comes from Ramapuram belonging to the late neolithic period. Construction of compound walls around houses in the Megalithic period, was a new aspect of community protection which was not known earlier. Single, double or even complex hearths, lined with clay were found inside the habitation. The technology used to build in the habitation area was still in its incipient stage and was primarily done with only perishable materials at first. Though there was a gradual use of stone in the Megalithic context for the first time, sun dried bricks were manufactured as observed at Gandluru.

During Period II called the early historic, roughly around the 4th century B.C. to the 4th century A.D. the settlements show an expansion. The size of structures with several improved facilities in the houses came into being. These settlements were laid out in well planned towns and included, apart from common dwellings, building complexes, enclosure walls, systems of water supply and sanitary structures. Besides, some public utility structures such as an amphitheatre, rest houses, public baths and ghats have also been found. The walls were of wattle and daub, brick and stone and some times, were plastered with lime. Roofs were laid with tiles for the first time. Improvement in covering the floors was observed by covering them with lime plaster or concrete. Walls were raised on simple foundation of rubble stones. Water was, for the first time, drawn from the ground by sinking wells. Waste water was taken away by drains both covered
The plans of houses now changed from circular to square and rectangular. Some houses were built on firm foundations. During Period II some buildings were also built with sophisticated technology as they were multi-storied dwellings with all the amenities. On the other hand, huts built of simple technology co-existed side by side with these sophisticated buildings. Nonetheless, there was a marked improvement in building technology of this period and we have a variety of buildings known to us not only from archaeological remains still extant, but also from literature and sculptural representation on contemporary buildings.

The limited information on building technology of Period III and IV helps us only to make some general inferences. At the beginning of Period III we have habitational buildings built with brick, lime, wood and tiles as has been seen from the details of the Keesaragutta excavation. The inscriptive and literary evidence suggest beyond doubt that there were buildings of different types used by the common people but due to lack of archaeological evidence the techniques of construction at each stage and in each type of building could not be assessed as was possible to do for Periods I and II. However, we can postulate that some of the dwelling structures must have been built of perishable materials, though the evidence of a considerable number of monumental buildings like temples which were built during this period indicate that permanent and durable building materials were available to the technologists of the periods. In this connection it is important to indicate that since resources from land and trade were available mainly to the King and Chiefs and other elites,
who were the main patrons of temples, they were in a position to experiment more freely with sophisticated building technology. Further, the technicians and artisans were also under their control. During Period IV, there was a proliferation in the building of monumental structures but the evidence for the houses of the common and poor people is again negligible. Inscriptions and literature do refer to different types of houses and some of them must have been made of perishable materials such as mud walls and thatched roofs, as a thirteenth century text Sukti Muktāvali of Jalhana suggests. This text also alludes to humble dwellings and the harrowing poverty that people lived in. In contrast, it was natural for the public utility buildings such as mathās, colleges and hospitals to be built with stone because of the munificent grants that were available from the landed elites for building and maintaining them.
FOOTNOTES


2. Atharvaveda V.1.11-37; Panini II.1.129: 3.99; IV.4.770; Arthasastra II.1.20.

3. Mili nda Panha. 62; Anguttara Nikaya. 1011; Digha Nikaya. 1.61; Jataka. I.200, 425 and Vinaya Piṭaka. 3.43.

4. K.V.Soundara Rajn, 'Stone Age Industries near Giddalur, District Kurnool', AI, no.8, p.64.


8. Ibid. p.198.


20. B.Narasimhaiah, Neolithic and Megalithic Cultures in Tamil Nadu, Delhi, 1980, p.80.


28. ARAP. 1982-83, p.44.

29. Ibid. p.44.


34. B.Narasimhaiah, OP. Cit.. 1980, pp.80-81.

35. Referred to in Karl, W.Butcher's Environment and Archaeology. Chicago, 1971, p.404. Muller-Wille recognises the following settlement types based on duration of site occupation as ephemeral. Settlements of a few days, 'temporary'; settlements of several weeks; 'seasonal'; settlements of several months, duration, 'semi-permanent'; settlements of some years duration and 'permanent' settlements lasting for several generations. See, Muller Wille, 'Arten der Menschlichen Siedlung', in Abul Akad, Raunforsch, Landesplan. (Bremen), vol.28, (Mortensen Frestshrift), 1954, pp.141-163.

41. Ibid. 1983, p.81.
46. ARAP, 1982-83, p.46.
49. IAR, 1983-84, pp.3-4.
51. ARAP, 1977-78, p.4.
53. Ibid. 1983, p.132.
54. ARAP, 1974-75, p.25.
56. ARAP, 1982-83, p.45.
57. IAR, 1982-83, pp.3-4.
61. S.B. Deo, 'Megalithic Problem of the Deccan', in *South Asian


69. JAR, 1983-84, pp.3-4.


73. ARAP. 1974-75, p.25.


77. Ibid, p.81.

78. IAR, 1983-84, pp.3-4.


83. ARAP. 1981-82, p.26, Pl.XII.


87. IAR, 1983-84, pp.3-4.
88. ARAP. 1982-83, p.45.
91. ARAP. 1982-83, pp.45-46.
95. IAR. 1983-84, pp.3-4
98. IAR. 1983-84, pp.3-4.
100. IAR, 1982-83, pp.3-4.
104. In the Miliṇḍapanha it is mentioned that 'Just as the architect of a city when he wants to build one, would first search out a pleasant spot of ground, with which no fault can be found, even, with no hills or gullies in it, free from rough ground, and rocks, not open to danger of attack, And then when he has made plain any rough places there may still be on it, he would clear it thoroughly of all sturrups and stakes, and would proceed to build there a city fine and regular, measured out into quarters, with excavated moats and ramparts about it, with stout gate houses and towers, with market places, cross-roads, street-corners, and public squares, with cleanly and even main
roads, with regular lines of open shops, well-provided with parks, gardens, lakes, lotus-ponds and wells, adorned with many kinds of temples of the Gods, free from every fault. And then, when the city stood there in all its glory, he would go away to some other land'.

See Miliṇḍa Panha. I-34.


107. Ibid. pp.139-143.


110. V.V.Krishna Sastry, OP. Cit., 1983, pp.129-130.


112. Ibid. p.338.


116. Ibid. p.9.


118. It is interesting to note that in the Nasik Inscription it is mentioned that Usavadata gifted quardrangular hermitages, dwellings and shelterhouses, See C.Sivarama Murthy's Amaravati Sculpture in Madras Government Museum. Madras, 1952, p.93.


126. Miḷiṇḍapānha, I.34.
128. Cullavagga, VI.3.11.
131. Ibid, p.5.
140. A few terracotta plumbobs have been recovered from the Yeleswaram excavations. At present these are under display in Yeleswaram Pavillion, Archaeology and Museums Department, Gunfoundry, Hyderabad. But the excavator A.W. Khan did not mention them in his report which was published as A Monograph on Yeleswaram Excavations. Hyderabad, 1963 (Chapter on Terracottas, See p.45).
145. T.N. Ramachandran, 'Nagarjunakonda', MASI. no.71, Delhi, 1938, Pl.XXX.A.
146. T.N. Ramachandran, Buddhist Sculptures from a Stupa near Golī, Madras, 1929, Pl.VI-F.
148. Mahāvagga, LXXXVII, 97; Vinaya, 3.43; Anguttara Nikaya, 101 and Samyuttara Nikaya, 1.61.
149. **Cullavagga.** Chapter 5 & 6.

150. This is based on my own observations of the construction of thatched huts in coastal area of Andhra Pradesh today.


157. A.Ghosh (ed.), *Encyclopaedia of Indian Archaeology.* vol.1, Delhi, 1989, p.126.


169. **ARAP,** 1971-72, pp.1-2; and 1972-73, p.4.


171. The process of excavating a well from ground water is based on my observations of such construction work in most of the coastal villages of Andhra Pradesh today.

172. These descriptions are also made based on my field excavation
experience at a good number of sites that I have attended to.

173. In writing these descriptions I have used my own observations based on the excavation reports.


176. _Ibid_, pp.211-212.

177. V.V.Krishna Sastry, _Op. Cit._. 1983, pp.139-141.


185. _Jataka_. IV. 229.


188. _Ibid_, p.259.

189. _Dhamma Atakatha_, I.269, 270.


194. Personal Communique wiith D.L.N.Sastry, Asst. Director (Excavatiions), Department of Archaeology & Museums, Hyderabad.


197. _Jataka_. I.189, 199, 200; III. 217.
198. An attempt at understanding the process of urban decay and revival of urban centres supported by strong rural agrarian settlements with market economy using epigraphical data, in the absence of substantial archaeological evidence, for the early medieval period has been made by B.D.Chattopadhyaya in his essay on 'Urban Centres in Early Medieval India: An Overview' in S.Bhattacharya & Romila Thapar (eds.), Situating Indian History. Delhi, 1986, pp.8-33. This can be contrasted with R.S.Sharma's views on the decline and decay of towns after the 3rd century A.D. which he has systematised in his publication, Urban Decay in India. Delhi, 1987. pp.132-141 and 167-183.


201. ARAP. 1975-76, pp.11-12.


204. Ibid. pp.39-40.

205. During a field survey in February 1991, Sri Gadiyaram Ramakrishna Sarma, a well known historian of Alampur and myself, observed the same at Alampur.

206. ARAP. 1975-76. pp.11-12.


208. Settlements known to have existed during the Medieval period such as Warangal, Alampur, Vengi, Kandur, Vardhamanapuram, Amaravati, Kolanupaka are superimposed by later day habitations which have continued to be inhabited till today.


210. Ibid. p.68.


214. Ibid. p.384.


227. Nannaya, the writer of the Mahabharata in Telugu language during 11th century A.D. mentions about the currency that was in circulation as Gadyanas and Gaddelu which were of gold metal. This has been corroborated by epigraphic and numismatic evidences of the period. See S. Dasarathi, 'Numismatic References in Nannaya's Mahabharata'• PAPHC. 10th Session, Guntur, 1986, p. 177. A.S. Altekar has reported a gold coin issued by Rajaraja, the Eastern Chalukyan King under whom Nannaya served as a poet laureate. This information has been referred to in G. Yazdani, Early History of the Deccan. vol. 11, London, 1962, p. 804. Similarly, the epigraphs of the period also mention Gadyas, i.e., Gadyanas. See SII. vol. VI, Inscription no. 1201. Further, a few gold coins of the Kanyakas bearing the legend dāvagajakesari were found from Suddala and Tarigoppula both situated in sub-region A.


236. **CTI**, vol.11, no.30.


239. *Ibid*, p.120.


256. AREAP, for the year 1965. Inscription no. 56.


259. SII, vol. IV, no. 1054.


261. ARE for 1929-30, Inscription no. 29.


263. SII, vol. VI, no. 904.


267. HAS, no. 7, p. 55.


II.2 IRRIGATION STRUCTURES
II.2 IRRIGATION STRUCTURES

The prosperity of any country depends upon its economy supported by agricultural revenue. To improve agriculture the States resort to artificial means of irrigation for the betterment of the economic standards. The emergence of State with a capacity to set apart huge amounts for the development of technology was one of the factors that led to the building of irrigation structures in early India. Private individuals, certain communities and local lords also helped financially and materially in this regard. In Andhradesa a number of irrigation related structures, originally located in the vicinity of religious structures, were dug and built, after a proper survey and selection of suitable water sources and command area under the guidance of technical experts who managed large number of ordinary labourers. In the following pages an attempt is made to explain the different stages of development in building technology of irrigation structures in Andhradesa beginning from Period I to Period IV of our study.

Irrigation is the artificial application or process of supplying water to crops in countries where the rainfall is insufficient or comes in the wrong season. In modern terms it is understood as a scientific practice which deals with the operation or system of conveyance of water through channels. It is commonly assumed that today irrigation represents a major departure from earlier agricultural practices involving radical changes in techniques. The earliest forms of irrigation were indeed small scale water-spreading techniques involving minimum amounts of investment and labour. The water resources for irrigation can be classified into two
kinds viz., natural and artificial. The former includes rains, rivers, tributaries, streams and small gullies, while the latter includes man made structures such as reservoirs, ponds, ditches, tanks, wells, canals and river channels.

The earliest irrigation activity from the archaeological record has been noticed at some of the Indus Valley sites. Writing on water sources of the Indus Valley people, Shereen Ratnagar points out that they might have depended on ground water, available in the form of aquifers as noticed in Kutch or in the remnants of summer inundations found at Larkhana, or in the courses of small spring-fed rivers like the Sind Kohistan. The Indus people are also said to have used lift irrigation systems for agricultural purposes.

The irrigation techniques after the end of the Indus Valley civilization, are known to us from statements in the earliest literary sources. In this regard we have some of the first references to irrigation facilities in the Vedas, the earliest literature available. For instance, the Rigveda mentions four sources of water, viz., from sky, sea, rivers and wells. The Yajurveda mentions additional sources of water from reservoirs and canals. Irrigation by wells, tanks and canals is also described alongside earthen dams. Transport of water through large bags of skin, a water-wheel and a moat have also been described in the Vedic literature. Panini mentions in the Astādhyāyī the yugavaratī to mean 'yoke' or 'rope' or 'strap', by which the bullocks were driven for drawing water. A long earthen bucket used for irrigational purposes has also been mentioned.
Among the various physical regions of the Indian sub-continent, the Deccan is a relatively dry area with limited seasonal rainfall and with a shortage of perennial rivers. The need to have water easily available and to avoid stress caused by drought and other causes must have led the earliest neolithic and chalcolithic communities settled in this part of the country to develop irrigation systems and also produce earthen water storage vessels. In this regard we have the first evidence of an irrigation canal from Inamgoan, a Jorwe site, in the western Deccan belonging to chalcolithic times. This channel was excavated in trough shape, running to a length of 420 meters with an average width of 6 meters at the bottom and 8.70 meters on the top. It probably received water from the stream coming from the north-east of the site. Its construction explicitly denotes the innovative skills of the chalcolithic people in creating an artificial irrigation facility to promote agrarian production in this area.

In proto-historic Andhradesa however, neolithic people had lived near places where water was easily available, i.e., near rivers, rivulets and water basins, as noticed at places like Budigepalli, Peddabankur, Kadambapur, Polakonda, Chinnamarur, Chagatur, Utnoor, Uppair and Somasila in sub-region A; Veerapuram, Belum, Billasargam, Ramapuram, Eelewarm, Nagarjunakonda, Gandlur and Gangivaripalem in sub-region B; Jami and Kesarapalli in sub-region C and Hulikal and Kundili Cherlopalli in sub-region D.

It is therefore, only from the megalithic phase of Period I of our study, that we see the emergence of an indigenous tradition of water
engineering, using a run off storage system such as reservoirs and cisterns to ensure an annual water supply within the perimeter of habitation sites as a means of supplementing naturally occurring surface water sources. The Megalithic people led a sedentary life and possessed a broad based subsistence economy, supported by a specialised technology which included the construction of large scale water controls. In this regard, N.R. Banerji points out that in south India, megalithic monuments are found located near large tanks which accommodated the rain water flowing from the slopes of the hillocks nearby. On this basis, he opines that the megalithic people possibly introduced tank irrigation in the south. Scholars like B.K. Gururaja Rao also observe that the megalithic people lived in villages consisting of a sizeable population indicated by the mass of organised labour, required for construction of huge sepulchral monuments and large irrigation tank bunds. E.H. Hunt is also of the opinion that the economy of the megalithic people was based on agriculture which was carried out by irrigation. Based on the evidence of palaeobotanical remains of rice and sugarcane obtained from south Indian megalithic sites, T.M. Srinivasan suggests that lift irrigation was in vogue towards the end of the period.

In Andhradesa too, Megalithic burials at a few places have been noticed in close proximity to the irrigation tanks or perennial rivers. This led Krishna Sastry to presume that these people were primarily agriculturists. Many of the burial sites of Period I have been noticed in the proximity of large irrigation tanks as at Budigepalli, Torruru, Kanukollu, Kadambapur, Polakonda, Rajagopalapet and Kethireddipalli in sub-region A. Only a single site with similar kind of tanks have been
reported from Nagarjunakonda in sub-region B. It may be presumed that these tanks must have supplied drinking water to the house holds located at these sites, as well as used for sustaining their crops. In our recent survey conducted at a megalithic site called Damaravai in sub-region B, we noticed a large number of dolmens, scattered on a chain of hillocks around the village. The slopes of the inner side of these hillocks gave rise to form a large tank, which was presumably utilised for both drinking water and for irrigational purposes. On the basis of the above evidence it is fair to surmise that large scale tank irrigation was initiated by the Megalithic people in early Andhradesa. [Map VI]

During Period II, i.e., from the 3rd century B.C. to the 3rd century A.D. of our study, which is characterised by the rise of state and urbanism, irrigation structures are found prolifically. Artificial resorts of water supply for irrigation purposes were initiated on a large scale to meet the water needs of the ever increasing agrarian and urban settlements of the early historic period. Water was collected during the rainy seasons in artificial reservoirs in order to tide over the situation during the lean period. We get considerable information on this subject from the literature of the period and epigraphs, which describe a variety of irrigation works for India as a whole. According to the Arthasastra of Kautilya, the chief means of irrigation during the 3rd century B.C., were rivers, lakes, tanks, reservoirs and wells mentioned through such terms as nadi. sara. tadaka. kūpa. utsa and adhara.

Kautilya generally uses the term setu or setubandha, i.e., reservoir, built by putting up dams on streams in the general sense of an irrigation work and refers two types of setus, viz., sahodaka. wells and tanks which
DISTRIBUTION OF IRRIGATION STRUCTURES IN ANDHRADESA PERIOD WISE
could be fed by such natural sources as springs, and aharavōdaka, tanks and embankments where water was stored. A clear reference to canals for irrigation in the Arthasastra is found in a sutra which points out that water was set in motion by digging a kāṭapratim, or a river dam and nadinibandhatoma or a tank. It further details for us four different methods for 'setting water into motion' in order to have the land irrigated. On the basis of their efficiency the methods in ascendant order were hand-moved or hastapratim, shoulder-moved or skander pravartim, lifted from tanks, rivers or Udghatam and machine-moved or strotavantra. Hand moved, obviously meant irrigation through manual labour probably suggesting that water was carried in pitchers from hand to hand. Shoulder moved probably meant the use of animal power, i.e., yoking bullock for drawings water with the help of a long rope. Udghatam in all probability referred to the method of lifting water from tanks, wells, etc., with the help of a contrivance with a long bamboo balanced on a level with a heavy load on one end and bucket on the other. Strotavantra was probably a kind of hydraulic machine with a wheel and buckets.

Kautilya further gives considerable information on supervision and maintenance of irrigation works. He mentions that one of the duties of nagaraka or city superintendent, was to have constant vigilance and inspection of places of water supply, roads and water courses. Sītadhvaksha. was supposed to have among other things the knowledge of 'water divining'. Samāharta was expected to record the number of water works (setubandha) and the sheds for drinking water in the area in his charge. The private ownership of irrigation works is evident from the fact that Kautilya considers tanks and reservoirs as immovable property of
an individual. The communal activity in building irrigation works is also noted by Kautilya. He suggests that all local people should cooperate in building dams, etc. He also points out that all those who build new tanks and dams (तत्कासेतुबंधनामेव नवाप्रवर्तने) should be given the benefit of exemption from taxes.

The method of construction, organisation and management of hydraulic machinery in oriental countries, including India, led to a debate which hinges on the theory of 'Oriental Despotism' as envisaged by Wittfogel. The essence of Wittfogel’s argument focusses on the nature of the tasks in large scale irrigation, including canal construction. He points out that for proper irrigation, a large quantity of water had to be channelled and kept in bounds and this could only be done by the use of mass labour. This labour had to be coordinated, disciplined and led by a controlling authority. Many scholars however, disagree with the theory of Karl Wittfogel, the proponent of 'Oriental Despotism'. According to Romila Thapar, the type of irrigation needed in any country is dependent on ecology, crops, land size, climate, water balances, soil and the actual mechanism of obtaining, transporting and storing water in addition to calendric activities. Irrigation in some cases, could thus be used both to supplement rainfall, in other cases to cultivate a second crop. In the early historical period in fact, the major form of irrigation was carried out by building bandhas or dams across small streams and converting them into tanks. These traditional small-scale irrigation works therefore, did not need a despotic centralized political authority to execute them. In the same way V.K.Jain, opines that in ancient India irrigation was provisionally conducted by such minor works as wells, tanks, ponds, etc.,
which did not require either the mobilisation of labour on a large scale or a powerful bureaucracy to organise and manage them. These works were owned and maintained by local people, individually or collectively. There is, however, evidence for the early period in India that Kings also took interest in providing irrigation facilities. Nanda Kishore points out that to cope with the famine both the people and the kings took special care to construct irrigation works of small as well as enormous size. The number and size of huge water works began to increase with the introduction of feudal elements in Indian polity during the early centuries after the Christian era.

A direct proof of the active interest taken by the Mauryan Kings in providing irrigational facilities is the Girnar rock-edict wherein we learn that in Saurastra, Sudarsana lake was constructed by the Governor of Chandra Gupta Maurya and then repaired by the Governor of Asoka. Except the Sudars'ana lake, there is no large scale irrigation work which may justify state enterprise in irrigation for the ancient Indian context, prior to the sixth century A.D.

The inscriptions of Period II throw some light on the methods and works of irrigation in the Deccan as a whole, which can also be taken into account while dealing with the irrigation techniques of Andhradesa in the early historical context. Sātavāhana inscriptions refer to the term hala both in the sense of a measure of land and an iron plough. The Nasik inscription of Madhariputra speaks of the guild of ōdayantrikas, the makers of the water machines. Usavadāta is eulogised as the maker of tanks or tadāka and wells udapāna. The Amaravati epigraph of the time of
Rajan Siri Śivamaka Sada, mentions a pāṇīyagharika, i.e., superintendent of water houses, possibly for controlling the distribution of water. The Myakadoni inscription of Pulumāvi records the construction of a large tank meant for irrigation. Symbols on the obverse of some early Satavahana coins from Kolhapur, represent the water-wheel used for irrigation. Further, the contemporary literature to Satavahana rule also furnishes some information on the irrigational techniques corroborating the epigraphic and numismatic data mentioned above. The early Buddhist text Cullavagga refers to the use of water machines for lifting water. The Gāthāsaptasāti mentions a water lifting device called rahattaghadia. The above discussion leads us to surmise that agriculture was the main stay of the people and that both kings and wealthy elites in society took interest in the extension of agriculture by creating and improving irrigational facilities. H.P. Ray rightly observes that judicious use of irrigation was responsible for increased agrarian productivity during the Satavahana period.

For early Andhradesa archaeological remains shedding some light on how water supply was organised are available from almost all the subregions of our study. These wells and cisterns dug near and around the habitation area found at Kotilingala, Peddabankur, Kondapur, Kudalisangameswaram in sub-region A; Nagarjunakonda in sub-region B; Majeru in sub-region C; and at Ramapuram in sub-region D have been dealt with above in the habitation buildings and public utility structures section of this chapter [Chapter II.1]. The excavations at Peddabankur in sub-region A have brought to light a good number of brick wells and cisterns. As many as 22 wells, all built in brick were noticed here. One of these was lined with terracotta rings. The wells were built with wedge shaped bricks of size 30 x 20 cms which is
a major technological breakthrough of the period. [Plate VI] Brick cisterns square and rectangular in shape were also brought to light in the Peddabankur excavations. Brick wells have also been reported from Kotilingala, Kondapur and Kudalisangamesvaram in the same sub-region. These wells enabled individual families and separate residential quarters, to have access to their own water supply and avoid drawing drinking water from surface water sources which must have been liable to pollution.

Interestingly, rock-cut cisterns and tanks meant for water supply and storage for Buddhist settlements are noted prolifically on the hills and hillocks in sub-region C. These have been found at Pavurallakonda, Bavikonda and Thotlakonda and Gopalapatnam. As these Buddhist settlements are located on hill tops and away from natural water sources, the Buddhists preferred to scoop the rock into troughs to collect and store rain water for drinking purposes during the period after the rainy season. These cisterns involve techniques of scooping the rock first, by levelling the rocky terrain, then marking the size of the cistern to be excavated and finally proceeding to excavate by removing the mass using the iron tools such as pick-axes, chisels and hammers. Steps were provided on one side to facilitate the Bhikkus to get into the cisterns in order to get the water by vessels. There are 16 such troughs at Pavurallakonda, six at Gopalapatnam, eleven at Thotlakonda and three at Bavikonda.

The techniques of scooping the rock into cisterns can be explained in the following manner based on the Thotlakonda examples. At Thotlakonda, [CHART IIB] a series of rock cut cisterns were excavated which were meant
### Period II: Irrigation Structures

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of the Site</th>
<th>Sub-region</th>
<th>Well</th>
<th>Tank</th>
<th>Type of Irrigation Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Nyakadoni</td>
<td>D</td>
<td>-</td>
<td>/</td>
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<tr>
<td>2.</td>
<td>Nagarjunakonda</td>
<td>B</td>
<td>-</td>
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</tr>
<tr>
<td>3.</td>
<td>Thotlakonda</td>
<td>C</td>
<td><img src="brick_icon" alt="Brick" /> <img src="stone_icon" alt="Stone" /></td>
<td><img src="earth_icon" alt="Earth" /> <img src="brick_icon" alt="Brick" /> <img src="stone_icon" alt="Stone" /></td>
<td></td>
</tr>
</tbody>
</table>

Key:
- ![Earth](earth_icon): Earth
- ![Brick](brick_icon): Brick
- ![Stone](stone_icon): Stone
- ![Rock-cut](rock-cut_icon): Rock-cut
for collection of rain water for use of the Buddhist settlement. Channels were provided where ever necessary along the gradients for a free flow of water, from the higher contours. Channels cut in the rocky surface connecting one cistern to another were apparently used for regulating the excess water from the cisterns at the higher contour. The floors of the cisterns were plastered with lime to arrest seepage, since the walls of cisterns could have fissures. All the cisterns were provided with steps [Plate IX], All around these a rectangular dry masonry rubble wall in lime mortar was constructed for probably preventing the animals access to the troughs. Occasional occurrence of post holes on the periphery of some of the cisterns indicate some sort of roof over them. The wells or cisterns covered with a shade are mentioned as *udapānaśāla* and *pōdhis* in Buddhist literature. In inscriptions found located near the rock-cut cisterns at Junnar, Ganeshpahar, Kanheri, Kuda and Nasik Caves of Western India, these water cisterns are specially called *pōdhis*. Drinking water cisterns were called *pānvapōdhi* and bathing cisterns are called as *sananapodhi* as has been noticed at the Junnar and Kuda Caves.

The situation of these troughs suggests that the selection of slopy parts of the summit for collection of maximum rainwater. On the southern side of the settlement at Thotlakonda, there is a big tank which was also probably fed by rain water. Attempts had been made by the experts to scoop the slopy inlets into the tank by trimming the boudary surface of the hillock, for a free flow of rain water into the tank which formed the main source of water for the entire settlement.

At Bavikonda, another site along the north Andhra coast there are
three tanks on the hill top. The tanks are oval in shape and vary in size from 30 x 50 meters to 135 x 90 meters. Here also the rocky terrace was chiselled as inlet channels to collect rain waters into the rock cut cisterns.

We have the earliest evidence of the construction of a large tank meant for irrigation from Myakadoni in subregion D. [CHART IIB] Being a semi-arid region, the cropping pattern in sub-region D mostly relied on the artificial irrigation facilities such as tanks and wells since the rainfall in this region even today is low. The sub-region has been called dry zone according to the study of M. Ramudu who has done research on the area and its irrigation facilities. This large irrigational tank at Myakadoni still serves as the main water storage system for agricultural purposes. The selection of the site for such a huge tank denotes the foresight of the people of the early historic period that it had a very wide catchment area for collecting rain water. The tank bund was constructed by earth not only from that which was dug out but also from that which was carted from the nearby areas for the purpose. Hundreds of bullock carts and a few hundreds of ordinary labourers supervised by a limited number of foremen, might have been employed in the work denoting a collective effort under the control of well trained and experienced technical people in building tanks.

During the 3rd century A.D., the people of Nagarjunakonda had tapped many sources for providing water supply to the city, both for domestic and irrigational purposes[CHART II B]. They primarily relied on natural sources of water. The river Krishna which is a perennial source of water must have been utilised to the maximum extent for this purpose. Besides
this, canals, wells and tanks were excavated. Canals were dug from rivers to feed tanks of small sizes which in turn were used as the main source of water supply to the fields by means of branch channels. Irrigation by means of inundation was also popular during the period. Evidence of an ancient canal on the eastern side of the valley reveals the engineering skill of the people during this early period. Farrington defines an irrigation canal as, "a delicate artifact, designed with engineering precision to transport a required amount of water from source to field in order to maintain an adequate soil moisture environment in the later".

According to R.Subrahmanyam, the above canal at Nagarjunakonda must have served as a substantial source of water for all the people. The water trickling down from the surrounding hills, through gullies was tapped and diverted into this canal by constructing a rubble cross wall. On either side of the canal, thick randum rubble embankment walls were built on a good foundation of hard gravel. The bunds seem to have been raised to a height of 2'-0 over the wall. The excavation in this canal have yielded typical Ikshvaku antiquities. This canal ran to a length of 100 meters with an average width of 50-0 and 6'-0 in depth. The building of this canal stands as testimony to the skills of the engineers of the Ikshvaku period. I.K.Sarma, opines that this canal might have served both domestic and irrigational purposes.

People of Nagarjunakonda did not allow the water flowing from nearby hill to go waste. They built a number of tanks with earthen embankments in semi-circular fashion as noticed on the southern fringe of the valley. [CHART II B] The embankments are found to be of morrum or red earth mixed
with rubble and gravel. The tank found near the university area, at Nagarjunakonda might have been fed by the waters of the canal already described above. At the foot of the Phirangimotu hill, some vestiges of another embankment of rubble with a sluice and drain have been noticed.

A rubble wall 17 feet in length with a sluice of brick masonry provided for regulating the out-flow of water was also noticed. Sluices are generally mechanical contrivances in the form of gates by which the flow of water can be controlled from the main canal into other branch channels. They are usually constructed on the tank bunds to allow the surplus water to flow out and keep the tank intact from developing cracks. R.Subrahmanyam opines that these tanks found at Nagarjunakonda were used for storing water for irrigation purpose.

Construction of wells in circular, elliptical, square or rectangular shape either in coursed rubble or brick, associated with residential structures have also been noticed at Nargarjunakonda. A well of huge proportions is found on the Nagarjuna hill area. This well about 160 feet in diameter, probably served as a water source for the garrison stationed at the fort on the hill top as R.Subrahmanyam opines. It is 80 feet deep and stands as a monumental example of the labour used in the execution of such a large scale excavation in rock. All round it had a retaining wall in brick. An Abhira inscription dated to the 30th regnal year of Vasusena refers to this excavation of a huge well called Vesisa Mahātada.

During Period II, a marked development is thus evident with advanced techniques in providing water supply to domestic and irrigational purposes through artificial means. To distribute the water, canals were excavated
which were provided with sluices for the first time in the early historical context of Andhradesa. The contemporary literature and epigraphs also provide information on the various modes of irrigation systems initiated by the royalty as well as wealthy individuals in society. The management of these water works was however, kept under the control of the local rural communities. It is only during this period that natural water was systematically tapped into low lying areas by building earthen embankments and stored for future use. Wells were also dug into soils where rain fall was low. The people possessed knowledge in excavating the wells and huge tanks in hard rock, as noticed at Tholtakonda and Pavurallakonda in sub-region C and Nagarjunakonda in sub-region B. [MAP VI]

Period III is considered as one of transition, from an ancient to early medieval economy. The latter has been described as feudal in character as an outcome of the land grant system. It is also to be noted that there was a growth in rural settlements as a result of the decline in trade and industry and these settlements became the nucleus of agricultural expansion. A recent study, on the Vishnukundin records made by Krishna Prasad Babu, reveals that all the records of the Vishnukundin period mention grama and village settlements, whereas only a few refer to puras. R.N.Nandi while studying the neighbouring Karnataka, during the period says that because of agrarian expansion due to the land grant economy there was also a gradual improvement in irrigation techniques. The extant archaeological remains relating to irrigation structures for this period are absent, save one or two examples. Hence we have to depend upon the contemporary perceptions mentioned in the epigraphs and literary works wherein references to excavation of tanks and wells are made.
Irrigation was carried out by wells and tanks during the Vishnukundin period as the Tunvnaigudem charter of Govinda Varma describes him as [Chart II C]. The Vilavetti plates of Pallava Simhavarman (A.D. 436-460) records the collection of tax from kupa darsakas which further reveals that there were some experts in water divining who approved of the sites proposed for digging wells. The British Museum plates of Charudevi, the queen of Pallava Yuvaraja Buddha Varma, record an irrigational tank called rājatataka, meaning the king of tanks. The above references show that irrigation was carried out by wells and tanks.

The tanks at Turimella in sub-region B, Chilamakuru and Kondapalli in sub-region D [Chart II C] were constructed during the period in order to bring the waste lands under cultivation, according to the inscriptions of places mentioned above. An inscription datable to the 9th century A.D. found at Gudimallam in sub-region D informs that the local tank was desilted by the Pallava king Danti Vikrama Varma. Another inscription from Avilala in subregion D dated to 867 A.D. of Nandivarma Pallavamalla III refers to a tank named Avilaleri [Map VI]. The above inscriptive evidences provided us information that in all most all subregions, agriculture was carried out only by tank irrigation. We have no other information as to how these tanks were excavated or built. On the other hand we have some information on these aspects available for the contiguous region of Tamilnadu. A Pandyan record datable to the 8th century A.D. shows that two distinct technical advances were made in building the embankments of tanks and the banks of canals. According to this inscription, dressed stones were pitched to the earthen embankments in place of the traditional rubble and laterite material, and these dressed stones were arranged to a stringline technique. Probably the same
### CHART II C

**Period III: Irrigation Structures**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of the Site</th>
<th>Sub-region</th>
<th>Well</th>
<th>Tan</th>
<th>Embankment/Dam</th>
<th>Canal/Channel</th>
<th>Sluice/Gate</th>
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<td>-</td>
<td>/</td>
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<td>-</td>
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<tr>
<td>5.</td>
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<td>7.</td>
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<td>-</td>
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**Key:**
- Earth
- Brick
- Stone
- Rock-cut
method of construction might have been adopted for the tanks of this period in Andhradesa too.

Regarding the methods of irrigation, we have a few literary evidences among which Medhatithi (825-900 A.D.) documents a method of irrigation known as the **Upamitibhavaprapaṭchakatha**, the early prevalence of lift irrigation by Persian water wheel and leather buckets. For this period in our area of study we have only one extant tank where we see a new irrigation technology, that resulted in the construction of a rock-cut and masonry dam, with underground channels, which were provided with sluice gates. This has been noticed at Gandharikota [Plate IX] in sub-region A. At the foot of the hills of Gandharikota was a concealed a rock-out channel with a sluice of the early medieval period, datable to the 8th century A.D. The sluice was actually cut into the natural rock of Gondwana series to a depth of 12'-0 to 15'-0 in semi-circular form and connected to a rock-cut rectangular channel of the same depth, and provided with a gate. Another sluice, cut into the well above the earlier one at a height of one metre, was intended for the outflow of water, from a higher level when the tank was full. Over this rock-cut channel, lay the ceiling slabs, serving both the purpose of covering the channel and also preventing the debris and other vegetable matter from falling into it. Interestingly, one of the ceiling slabs has a hole of 0.45 metres in diameter, probably meant for manual operation of the sluice gate. The above information leads us to surmise that the people had sound knowledge of surveying the surroundings before selecting the areas to be utilised as tanks. The arrangement of the sluice gates, and rock-cut channels for inflow and outflow of water can be taken as a technological advancement in creating irrigation facilities and
Period II: Rock-cut cistern, Thotlakonda, **Sub-region C**

Period III: Rock-cut canal, **Gandharikota**, Sub-region A
indicates the engineering skill in regulating water without letting it go waste. These mark unique achievements in the rock-cut technology for irrigation purposes. The water supply system of Gandharikota is an excellent example, without parallel, of a well-planned and superbly realised hydro-technical project, which has demonstrated its capacity to resist the destructive powers of nature and human disasters and thus survives till today. The same technology has been in operation for more than 1000 years and still serves as a working water management system.

To assess the building technology of the irrigation structures of this period, we have only epigraphical information for Andhradesa on one hand and the solitary example of a unique rock-cut tank on the other hand. As the epigraphs of the period refer to excavation of tanks and wells it can thus be surmised that most of the area in all the sub-regions was irrigated by tanks excavated and we can notice an increase in the number of tanks when compared to Period II. The earthen embankments were made by depositing earth either by cart or head loads with an involvement of large amount of labour. The only extant archaeological remain of a rock-cut tank at Gandharikota reveals that the people of authority were responsible for financing to create such a unique hydrological project.

The building technology of irrigation structures of period IV can be studied based on literary, epigraphic and extant remains, found in our area of study. This period sees changes in two stages, namely, stage I and II i.e., from 1000 to 1200 A.D. and from 1200 to 1400 A.D. respectively. During stage I of the period, only digging of tanks, canals and wells was known, whereas in stage II, massive earthen dams were built for
irrigational purposes besides continuing the earlier methods. This classification also facilitates us to compare and contrast the technological developments from one stage to another in each sub-region. During stage I irrigation technology was continued or developed with new devices such as construction of large scale reservoirs with a net work of controlling canals and distributary channels. It must be emphasised that many of the tanks and lakes of the period even today continue to supply water to some thousands of acres in sub-regions A and B. Most of the tanks, wells or canals were dug at the instance of kings, queens, chiefs commanders, local communities and even private individuals. The state during the period IV had its economic base in agricultural productivity which was subsequently achieved through proper water management. The facilities for year round storage had intensified cultivation through irrigation of second crop. The rulers realised that irrigation was a major technical innovation to improve the efficiency of the local agricultural systems. The hydraulic modifications of the environment had included embankments to expand the water catchment area, dams to impound water for surface storage in order to recharge ground water and to transport water through canals for cultivation.

In Stage II i.e., specifically during the Kakatiya period there was an acceleration of irrigation by tanks, reservoirs, dams or canals. Irrigation water was considered as a catalyst for bringing a change in production through use of better technology of dry land agriculture. Since water management technology is location specific technology and has to be developed in different soil or climatic environments, the Kakatiya administration, through their feudal lords spent huge amounts on creating irrigation works. For providing irrigation to the farmer's satisfaction on
the one hand, and ensuring better use of water on the other, many methods were used or strategies evolved by the Kakatiya monarchs particularly since the choice of irrigation method depended on land topography, soil characteristics, quantity of water available and so on.

During the period, excavation of large tanks and canals was also evident from the contiguous regions to Andhradesa. In this regard we have some evidences of such works executed by the later Chalukyas in Karnataka and Cholas in Tamilnadu. The Later Chalukyan queen Rayamati built a large reservoir which was connected to river Saraswati by a 300 feet long channel. Recent archaeological operations have brought to light arrangements of stone sluice gates to inlet the water into the lake. Likewise in Tamilnadu, according to Tiruvalangadu plates, Rajendra I (A.D. 1012-1044) had celebrated his victory in the north by constructing a large irrigation tank Cola-gangam, and an embankment 24 kilometers long and was provided with sluices and canals for the irrigation of a larger area.

The literature of the period also provides us information about the excavation of tanks, canals and sluices along with some technical details. Narmada classifies the dykes into two types, i.e., kheya which were dug into the ground and the other called bandhva which were constructed above the ground level. The former represent wells and canals whereas the latter represent the embankments, i.e., tanks, Vijñāneśvara (1076-1126 A.D.) in his Mitākṣhara mentions that building of tanks and other irrigation works was looked upon as of fundamental requirement of society. According to another medieval work lekhāpaddhati, the government had been divided into
32 departments among which the **vārigrihakarana** functioned to looking after the construction, maintenance and repairs of water works. The **Pratapa Charitra** mentions that Ganapatideva had built big tanks at Nellore, Ganapuram, Elur, Gangapuram and Ekasilapuram. The **Sivayogasāram** mentions that Annaya the minister of Induluri family has constructed many tanks along the banks of Krishna and Godavari rivers respectively.

For the second stage of the period under study in Andhradesa we have some information on hydrology and irrigation facilities recorded in some inscriptions, which reveal the traditional system of the use of water sources and methods of dam construction in South India. In this regard an inscription from **Porumamilla** dated to 1369 A.D. [CHART.IID.29] in sub-region D records that a reservoir called Anantasagar was built by Bhaskara Bhavadura, by employing 1000 labourers and 100 bullock carts every day to get stones from the quarry for the masonry dam. This dam was built to a length of 500 *rekhadandas*, 8 *rekhadandas* in width, and seven in height. The inscription also quotes the verses from **Hemadri’s Vratakhanda** and enumerates as many as 12 *sadhana*s which were essential for building a reservoir. They included such things as a king with righteousness, a Brahmin having knowledge in hydrology, i.e., Pathas **sastra**, the availability or ground with hard **clay**, a river with sweet water, a hill in contact with the reservoir, a **dam** built of stones in between the hills, two extreme points, a deep and extensive bed, a quarry with straight and long stones, level and fertile land in the neighbouring area, a water course i.e., a sluice built of strong stones and finally, a gang of skilled men in the construction of dams. The inscription further says that with these essentials, an excellent tank could easily be built. It also enumerates six faults to be noted while constructing a reservoir such as water oozing
from the dam, saline soil, situation at the boundary of two kingdoms, elevation in the middle of the tank, scanty supply of water or extensive stretch of land and scanty ground and excess of water. All the above criteria to build a good tank tally with the extant reservoirs of the Kākatiyas.

The epigraphical records of the period provide information, that tanks of enormous size were built by the Kings and his subordinates. For instance, the Chiefs of Kanduru, Velanadu, Chāgi, Parichchedi, Eastern Ganga, Chola, and Kakatiyas have directly taken up excavating the tanks for irrigation purposes. An inscription dated to 1041 A.D. mentions that a Kadamba Chief has constructed a tank in Sabbinadu in sub-region A. The Kanduri Choda King Udayana Choda has built a tank at Nelakondapalli in sub-region B. Kulottunga Choda Gonka of Velanadu has constructed a tank at Timmapuram in sub-region C in 1161 A.D. The Parichchedi King Kusumāyudha had built two tanks in 1222 A.D. at Prattipadu in the same sub-region. A Chagi Chief Potaraja had excavated two tanks in 1230 A.D. The Eastern Ganga King Indravarma built a tank called Raia Tatāka at Achutapuram in sub-region C. The Chola King Rajendra Chola I had excavated a tank at Mekalachampalli in sub-region D in 1016 A.D. The Kākatiya King Prola I is credited with construction of a tank at Kesamudram in sub-region B. Rudra had built a big tank at Panugallu in sub-region B. Ganapatideva had built tanks at Nellore, Elur, Ganapapuram and Ekasilapuri in sub-regions B and C [Chart II D]. The Nirōstvakāvva of Hanumakonda reveals "In the country are hundreds of tanks". The Kākatiya Kings excavated hundred of tanks throughout the length and breadth of their country. The ideology of the period might have prompted the Kings
because construction of a tank was regarded as an act of a charity and one of the seven meritorious acts called as the Saptasantanas.

In addition to the State's direct involvement in constructing irrigational works, there are also a few instances to show that the local bodies such as Prabhus and Nadu assemblies have also contributed their mite. An inscription from Nandikandi in sub-region A databale to the 12th century A.D. refers to the excavation of a tank called madivājanakere and a gift of some land by the Prabhus, the local body of the village, to those people who actually dug the tank. In another instance, the Attirala Inscription records that the nādu assembly, i.e., an assembly of local bodies governing at district level called Pottapinadu decided to construct a bund on the river Cheyyeru by raising contributions from each of village the said assembly, to prevent the possible damage to the temple at Attirala. In this case it is clear that though the temple was built by royalty, it was considered as a common property of the entire district. This type of evidences mentioned above proves beyond doubt that the construction and maintenance of such works were also undertaken at the community level.

Information available from inscriptions of the period regarding the different types of irrigational works has been thoroughly utilised in writings that have emerged from the 1960’s onwards on the social, economic and cultural history of the period under study. The study of technological aspects of these irrigation structures however remain unresearched. Hence an attempt to understand the level of building technology of these structures is made by us. Special emphasis was given to the remarkable hydro-technical installations in the Kakatiya Kingdom.
among which the huge lakes at Ramappa, Pakhal, Ghanpur, Lakhnavaram and Bayyaram are important built during the regnal period of Ganapatideva [Chart IID 23, 24, 10, 16, 5]. According to an inscription the Ramappa lake at Palampet was built by Recharla Rudra, the Commander-in-Chief of Ganapatideva in 1213 A.D. The Pakhal lake was built by Jagadalu Mummadi in the 13th century A.D. Suitable sites were selected as at Ramappa, Ghanpur and Pakhal where the embankments were made to impound rain water and to capture it from a relatively gentle slope drawing from the ridges behind these lakes. In each case the bunds were built in between two hills connecting both. The length of the bunds at Ramappa, Ghanpur and Pakhal measure 2000 ft, 7000 ft, and 4500 ft, with a width of 30ft, 25 ft and 50 ft respectively. The height of the bund at Ramappa was 56 ft, at Ghanpur it is 48 ft whereas it is only 30 feet at Pakhal. There are 4 channels at Ramappa and Ghanpur, whereas the Pakhal lake has 40 channels [Map VI].

During the period the embankments were always raised by throwing up earth, all around the tank bed, on the plains and level areas. In the hilly tracts, the task was much easier than in plains and a group of hills could be easily joined together. We now discuss the details as to how the dam at Ramappa was built during those days. The basal width of the dam at Ramappa comes nearly to 100 ft. This embankment which stretched for 1 km long was connected to two hills on either side. The engineers planned that the rain waters from the hills and ridges, automatically collect and form into a reservoir. The tank bund at Ramappa was designed in such a way that it had a slope both towards the inside and the outside with a flat top facilitating the excess water to overflow, what we call now a days a spillway [Figure 5]. To avoid any type of erosive cutting of the earthen
### CHART II D

**Period IV: Irrigation Structures**

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<th>Canal/ Channel</th>
<th>Sluice/ Gate</th>
<th>Spill way</th>
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**Key:**

- Earth
- Brick
- Stone
- Rock-cut

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<th>Name of the Site</th>
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Key:
- Earth
- Brick
- Stone
- Rock-cut
Period IV: Details of an irrigation structure at Palampet, Sub-region B

dams of the period, which would divert water from human use, the hydrologists planted trees and pitched stones on the inner face of the bund, to protect it from the ravages of periodic floodings, a feature noticed at Ramappa and Ghanpur lakes. In this regard we have an inscription which mentions that rows of trees called Kattava were planted on the tank bund of the period with a view to add strength to it and also to preserve the bund from erosion. The sluices were built on either side of the bund not only to regulate the water supply but also to protect the foot of the spillway from erosive action.

Removal of silt deposit from the reservoir's bed continued as a recurrent activity when situation demanded and this was organised by individuals or, collectively, at a communal level. The above observations on the tank at Ramappa reveals that the people who were actually involved in building it possessed high degree of technical knowledge. This tank still serves as a water source for nearly 4,350 acres. P.Sreenivasa Char rightly quotes the description of this tank as given in the Palampet Inscription of Recherla Rudra that states: "which stands like an ocean that has come either from fear of the submarine fire and looks like a mirror of the city". Gulam Yazdani similarly speaks highly of these tanks. He writes: "Warangal, the metropolis of this dynasty (Kakatiyas) abounds in magnificent tanks and the titanic dykes and sluice gates of Pakhal, Lakhnavaram and Ramappa lakes are object lessons even to the modern engineers". The above study reveals that major irrigational works were built in stage II of period IV and it is interesting to note that all these hydrological projects were invariably located in sub-region B only.
Canals were dug to feed the tanks from the rivers and rivulets or to carry water from tanks to the fields. Inscriptions of period IV also refer to canals and channels dugout from the rivers and streams for irrigation purposes. Evidence of canals or channels dugout from the rivers Vamsadhara, Saptagodavari, Krishna, Gundlakamma, Naguleru and Swarnamukhi in sub-regions A, B, C and D are available. [CHART.IID]. Two canals, Rāvasaharamalla Kalva and Gandapendera Kālva were excavated from the bed of the Cheyyeru river at Lembaka and Tadlapaka in sub-region D during the 13th century A.D. At Kolanupaka in sub-region A, a canal by name Vamsavardhana Kalva was drawn from Aler river to feed a tank which was dug in 1279 A.D. The Amarabad Inscription dated to 1290 A.D. refers to a canal dug from the local stream called Pogasirivagu. Canals were also excavated at Palampet, Ghanpur and Pakhal in sub-region B. The method of excavating canals can be deduced on a close look of those found at Ramappa lake. For this a low gradient was selected and these canals were dug out accordingly, to a length depending upon the discharge and storage water of the respective tank. Sometimes these canals were cased with stone which were called as Kattumgommus. The others which had earthen embankments were called as Ana-Kālvas in the inscriptions of the period. Several such canals used for irrigation purposes have been described. Maximum numbers of canals were excavated in sub-regions B and D where the rainfall was low and the fields purely depended on artificial irrigation facilities.

As in the earlier periods irrigation was also carried out by well water during the period IV. Well irrigation was preferred in the areas where there was water scarcity or low rainfall, particularly in Palnadu area of sub-region B and Rayalaseema area in sub-region D. Excavation of
wells was mainly taken up by private individuals as this was small scale irrigation. Information on state's participation in excavating wells is not forthcoming. A few inscriptions from sub-region C and D furnish data on well irrigation from stage I of the period [CHART IID.4,11,12]. A well was excavated by certain Malla at Gumudur in sub-region B according to an inscription datable to the 11th century A.D. found at the same place.

An inscription from Badnehalu near Adoni in sub-region D dated to 1055 A.D. refers to a certain Pergade Virarakshasa who caused the construction of a well in the black cotton soil. The inscription also mentions that a gift of 12 mattars of land was made by him for its maintenance to attend to frequent repairs.

An inscription dated to 1237 A.D. from Gudivada in sub-region C [CHART IID. 11] refers to the construction of a well with bricks by Gudivada Pdtanaboya, who appointed a person to draw water from this well and supply it into a Kaluqadi, meaning a downward water channel, built of stone for easy flow of water into the fields. There was an explanation as to why the well was cased with bricks. The soil around Gudivada was black cotton soil where the well was dug and the earthen walls of the well are liable to collapse anytime causing inconvenience to draw water if they were encased. Pōtanabōya who belonged to an agro-pastoral community must have had earlier experience in this regard, which led to the construction of the well with bricks to prevent its collapse. Similarly, the earthen bunds of the canal were also liable to breach and collapse, especially when the canal carried water to its full velocity. In order to overcome this casualty, the inner sides of the canal were lined with stones as a permanent measure. The construction of wells and canals lined with brick and stone denotes a
development in building technology in stage II of the period as unlined wells were found in stage I.

Certain devices were used to draw water in well irrigation among which etam and ratna are mentioned in the inscriptions of the period. The Hanumakonda inscription mentions etam while the Dosapadu epigraph refers to a ratna. These are found mentioned in the form of a gift along with necessary wood and bullocks. In addition to the above, other devices called guda and mōta were used to lift the water. The term gēda is a device made of palm leaf or bamboo matting, in the shape of a bucket either end of which was tied with ropes and these ropes are held by two persons. To fill the bucket, the operating people bend their bodies to the front and then draw the ropes in order to empty the water in a channel dug at higher level. Etam was a device in which an iron or leather bucket was tied to a pole fixed horizontally in between two vertical posts. At the other end of the horizontal pole, a counter weight, probably a stone was tied. A single man could operate it manually by pulling it up and pushing down. Irrigation by means of draught animals was known as mōta. In this system water was drawn by buckets which were tied to the yoke. The bulls moved forward and backward while drawing the water. In order to do this an earthen ramp with a downward slope was necessary at the well. In the last system called ratna, a pulley was fixed to a wheel arranged with a number of small buckets. The wheel fixed vertically was mechanically rotated by a horizontal wheel whose movement was made by a pair of oxen rotating around the well. Maximum water could be drawn by this method when compared to the above methods. All the above devices are still in use to draw water in dry land and semi-arid agricultural zones in sub-regions A, B and D.
We do not have clear cut evidence on the exact cost involved in building irrigational works of the period. Only a few inscriptions mention the amounts spent for raising some of the tank bunds. An inscription 129 datable to the 13th century A.D. from Amarābad in sub-region A informs us that a certain Mallisetti met an expenditure of 30 mādas towards the charges for constructing a bund of a tank belonging to Swayambhudeva. Similar evidence comes from an inscription dated to 1272 A.D. found at Attirala in sub-region D which records that the residents of Pottapinadu met in the premises of Parasurameśvara temple at Attirala and they decided to raise on māda from every village in the district to meet the expenditure for constructing an embankment on the side of the river Cheyyeru in order to prevent the damage to the temple from the floods. Another inscription 130 dated to 1293 A.D. from Tripurantakam in sub-region B refers to the cost of construction of two tanks in the village of Pedapulacheruvu. The inscription also mentions that a certain Reddy had spent 241 golden Gadvānas. for building a tank called Kumārasamudra and one lady Potasani had spent 156 golden Gadvānas. for building another tank called Tripurasamudra at the same place.

The evidence from the above inscriptions reveals that the amounts were spent by individuals and the cost in each case varied depending upon the quantum of the work done. As there was no unitary rate available for a standard quantum of work mentioned in either literary or epigraphical source, we can not assess the exact cost involved for the execution of a particular work. The cost included the payment towards the wages of the people, both technical and non-technical, engaged for the supervision and
digging and bunding; the charges for the bullock carts engaged and the expenditure incurred towards the purchase of necessary material in this regard. In the absence of the evidence of the cost of the construction of tanks taken up by the state, it can be fairly surmised that all the above expenditure might have been met in kind or land. In one inscription it is mentioned that Kakatiya Ganapatideva granted lands to the priest Manchanarya for the construction of a fine tank.

Big hydraulic works required expert people and one such was called a Jalasutrada. Though we do not have any direct reference to them from Andhradesa, an inscription from contiguous region or Karnataka dated to 1388 A.D., speaks about the accomplishments of the hydraulic engineer, Jalasutrada. Singaya Bhatta who was the master of ten sciences, dasavidyāchakravarti. The inscription further mentions that he led the river Pennar, through a channel from Kattudi to the Siruvela tank at Penugonda in sub-region D and gave it the name of Pratapa Bukkaraya Mandalakaluva. The Porumamilla Tank Inscription of the same time also mentions the requirement of a Brahmin who was well versed in Pathasastra i.e., knowledge in hydraulics. Based on the above information we can surmise that the Kakatiya Kings who built massive dams at Palampet, Ghanpur, Pakhal and Lakhnavaram seem to have utilised the services of experts in hydro-technology.

The construction of large tanks and big dams of the Kakatiya period further indicated the involvement of different social groups. These specialised groups engaged in building large tanks and irrigational works were called Upparas and Vaddars. Some records from Nellore district provide information in this regard. A Machavaram record of the 16th
century A.D. mentions that some grains were collected from the farmers who raised crops from the wet lands that were distributed water from the tanks of Machavaram, Kandukuru, Mopadu and Kondamudempalli. The same record also says that the grain was to be given to the people called Upparas, Vaddars and Pedabovas, who were looking after the works of digging, maintenance and repairs to the tanks. Even today the same people are largely engaged in major irrigational projects in Andhra Pradesh. These people temporarily pitch up their tents at the work spots and stay there until the work is completed and after that they return to their native place and attend to agricultural work. For the maintenance of such people, land grants called dasabandha were given. An inscription dated to 1387 A.D. from Maredipalli in Anantapur district of sub-region D, refers to a dasabandha grant to two persons who dug a feeder channel to a tank of that village from the rivulet Chitteru.

The above study reveals that natural irrigation by way of run off-storage system was practiced at some alluvial pockets in Period I. During Period II, in order to have more secure supply of water, the people exploited ground water by digging permanent wells and tanks for the first time. Techniques of cutting through rock to top aquifers were the innovation of the period as applied at Thotlakonda in sub-region C. These irrigational works were built with limited technology financed by people at local, regional and central levels. A further development in building technology was observed during Period III in the form of excavating large scale tanks with canals and control systems. Spread of irrigation tanks in almost all sub-regions has been noticed.
The evolution of technology of the irrigation structures of Period IV reveals that the irrigational works were built by the Kings, ministers, feudal chiefs and individuals. The irrigation structures included wells, tanks, lakes, canals and sluices. During stage I of the period, irrigation was carried out by wells, tanks and canals. During stage II, major hydro-technological projects were taken up in the whole of Andhradesa. Local bodies had also contributed for building and maintenance of these structures. A major change from stage I to II was selection of hilly tracts to locate large tanks by building massive earthen dams in between the hills. The bunds were built by earth and sometimes pitched up with stones. Trees were planted on the bunds to protect them from erosion. Lengthy canals with distributary channels were connected to the stone built sluices of the tanks. Canals were also dug from rivers and rivulet to feed the tanks. Canal bunds were lined with stones. Major irrigational works and canals are located in sub-regions B and D. Wells were also lined with brick during this period. Water lifting devices like etam and ratnam were employed to draw a large quantum of water on economical basis. Experts in hydro-technology and specialised groups for digging and making embankments were engaged. During the period a large area of land was brought under active cultivation by building many irrigational structures throughout Andhradesa. Thus in a study of the evolution of the building technology of irrigation structures it can be concluded that simple and limited technology was available for protohistoric period when water was used for irrigation purposes by run off storage system.

During Period II, a notable development in water supply and storage systems was observed in the excavation of wells and tanks which were encased with bricks and cordoned with high bunds respectively. When
compared to the earlier dependence on natural water sources in Period I, these were definitely a marked achievement. A further improvement in water supply was observed at a good number of habitations situated on hills. To conserve the water for further use, where natural water sources are within their reach, the people excavated tanks and cisterns in hard rock as seen at Thotlakonda, Pavurallakonda, Gopalapatnam and Bavikonda. The technological development in metallurgy also facilitated in manufacturing iron and steel implements used to excavate the hard rock. A good number of wells and tanks were also excavated as small scale water works continued to be supported by royalty and wealthy individuals who had the services of specialists at their disposal.

Most significantly, many of the tanks built or excavated in early medieval times in Andhradesa are still in use irrigating several acres of lands as noticed at Tummalagudem and Gandharikota in sub-region A; Turimella in sub-region B and Avilala, Chilamakuru, Gudimallam and Kondapalli in sub-region D. Noteworthy progress had been made in the field of irrigation technology in Period III in providing large scale water controls, in the form of especially tanks and their discharge channels.

The culmination of irrigation technology in Period IV has to be related to the state's ability to spend large amounts of money on these installations, with the help of both technical and non-technical people. Thus, the final operation of hydraulic installations at huge lakes like Palampet, Lakhnavaram, Ghanpur, Bayyaram and Pakal are a few examples which help us assess the extensive basis of water storage that was developed and these can be said to be 'object lessons' to modern irrigation engineers.


4. Ibid. p.17.


8. Ibid, X, 101-5.7.

9. Ibid, V, 85.3.

10. Ibid. VII, 18.8,9.

11. Ibid. III, 32.15.

12. Ibid. X, 93.3.


14. *Aṣṭādhyāyī*. III. 3-12.3 also see V.S. Agrawala, *India as Known to Pāṇini*. Varanasi, 1933, p.204.


16. The sites are listed based on the survey reports on neolithic and chalcolithic sites in Andhra Pradesh that are available with various departments such as the State Department of Archaeology and Museums, Hyderabad, Archaeological Survey of India, South-Eastern Circle, Hyderabad, and Birla Archaeological and Cultural Research Institute, Hyderabad. See also V.V. Krishna Sastry, *The Proto and Early Historical Cultures of A.P.*. Hyderabad, 1983, pp.1-42.


22. Ibid. p.103.


24. E.Siva Nagi Reddy, 'Survey Report on Megalithic Site at Damaravati in Warangal District. 5-7 June 1993; (Typed) available with Department of Archaeology & Museums, Hyderabad.

25. Arthasastra. II.24-18; II.38-4, III.9-2; III.9-3; III.9-33.

26. Ibid. II.1-20.


30. Ibid. II.35.3.

31. Ibid. II.8-2.


33. Wittfogel Proposes two types of farming viz., hydro-agriculture and hydraulic agriculture. According to him, hydro-agriculture represents minor irrigation works such as wells, ditches which can be built by local individuals fairly or a group of people whereas the hydraulic agriculture is carried out under the large scale irrigation works such as tanks, channels which require organisational patterns and social control of the State. Summarised from Karl Wittfogel, Oriental Despotism: A Comparative Study of Total Power. New Haven, 1959 (Reprint), pp.3-12.

34. Ibid. p.18.

35. R.Thapar, From Lineage to State. Delhi, 1984, pp.75-76.

37. K.Nanda Kishore, 'Hydraulic Agriculture in Peninsular India c.300 B.C.-1300 A.D.', PIHC. Waltair Session, 1979, p.211.

38. R.S.Sharma, Indian Feudalism (c.300-1200 A.D.), Calcutta, 1975, p.42.


41. Ibid. Inscription no.15.


45. J.Allan, Catalogue of Coins of Ancient India. London, 1936, pl.XXXII.

46. Cullavagga. v.62.

47. Gāthāsaptasati. 490.


50. Ibid, p.143.

51. Ibid. p.142.


56. ARAP. 1992-93 (cyclostyled), p.16

57. V.V.Krishna Sastry, 'et al, Thotlakonda (A Buddhist Site in Andhra Pradesh), Hyderabad, 1992, p.15.

65. I.S.Farrington, 'The Archaeology of Irrigation Canals with special reference to Peru', WA, vol.11, no.3, p.287. He further says that the construction of a canal must be exact because lack of awareness of, or inattention to the principles of open channel hydraulics by either boulders or operators may result in severe erosional or depositional problems. Water losses from an irrigation system generally occur during conveyance. The construction, shape, form and gradient of an archaeological canal provide a valuable record of its engineering qualities and of the hydrology of the irrigation-agricultural system. The construction technology of canals and other irrigation devices is critical to the efficient operation of a system, for a canal must be built precisely to carry a set amount of water at permissible velocities with little or no damage to itself. This is a summarised version of his above cited article.
69. Ibid. p.40.
70. Ibid. p.40.
74. EA, vol.11, p.15.
75. SII. vol.XII, pt.2, Inscription no.5.
79. **Ibid.** no.3.
80. **ARE**, 1903, no.226.
81. **Ibid.** 1937-38, no.188.
82. **SII**, vol.XIV, no.44.
85. **ARAP.** 1990-91, pp.11-20 (cyclostyled).
89. *Mitakṣarā*. II-156.
94. **ARE**, 1941-42, no.9.
97. **Ibid.** no.269.
98. **Ibid.** no.275.

100. *ARE*, for 1931-32, no.190.

101. *HAS*, no.13, p.49.


107. *ARE*, 1960-61, no.100

108. *Ibid*. 1911-12, no.404


117. *Ibid*. p.82.


121. For more details on canals of the period, see Y.Gopala


123. HAS, no.13, p.81.


125. Ibid. vol.V, no.213.

126. HAS, no.13, p.24.

127. Ibid. no.18, Ng.3.


129. HAS, no.19, p.40.


132. FC, vol.X, Gb.no.6, p.212.


136. ARE, 1918, no.819.