

DEVELOPMENT OF ENGINEERING AND TECHNOLOGY IN INDIA FROM
1000 B.C. TO 1000 A.D. AS REVEALED IN *RĀJATARANĠINĪ*

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INTRODUCTION

The historical treatise entitled *Rājataranḡinī* written by the great poet Kalhaṇa is justly famous for giving quite an accurate account of the reigns of different kings who ruled the beautiful Kashmir valley or *Maṇḍala* as it was called. The history of the period from almost the beginning of *Kaliyuga* (c. 3050 B.C. to 1150 A.D.) is given in this work. It is mentioned in *taranḡa* VIII, *śloka* 3400 that Kalhaṇa began writing this treatise in 1148-49 A.D. and completed it by the next year. Jonaraja has also confirmed this date.

Kalhaṇa was the son of Chief Minister (*mahāmātya*) Campaka who served King Harṣa during the period 1089-1101 A.D. Kalhaṇa, therefore, must have had direct access to the materials in the royal archives and other sources from which he could write such a detailed and almost accurate history of Kashmir. Sir Avrel Stein, who had translated the treatise into English with ample notes and a scholarly introduction, appears to be very much impressed by the painstaking and accurate accounting of the history of the above period by Kalhaṇa. According to him, Kalhaṇa was a scholar, poet, and *paṇḍit* and in addition could be called an able archaeologist who made use of stone inscriptions, copper plate grants, and other papers to write the history of Kashmir. The place names, the structures, etc. that are mentioned in this treatise can be found even these days indicating the accuracy of the history described by Kalhaṇa. Stein had shown that there is some discrepancy regarding the reign periods of different Kings, particularly, upto 5th century B.C. It is, however, difficult to understand who had given the correct dates, Kalhaṇa or Stein. According to Kalhaṇa the great Buddhist emperor Aśoka ruled much before 1182 B.C., whereas according to different evidences, fixed particularly by Western scholars, Aśoka ruled in the middle of the third century B.C. Nonetheless, it can be undoubtedly suggested that at least the chronological order of the kings and the history thereto is correct.

The value of this historical work is considerably enhanced by the accuracy of the reporting of the historical events without any bias, and by the sense of responsibility of the author regarding the importance of the periods of different kings he had given. I have, therefore, chosen this treatise for collecting information regarding the development of Civil Engineering in India with the passage of time. Another reason for this choice is the availability of a considerable volume of information on this aspect in this treatise. It may be noted further that the information given in this treatise can be confirmed from available archaeological and geographical information. It is, therefore, thought that this is one of the best ways to describe the history of advancement of Civil Engineering as far as Kashmir is concerned. It need not be presumed that engineering as a science and practice of the same status might have prevailed in the other parts of India as well.

GЕOMORPHOLOGICAL INFORMATION

A number of geomorphological phenomena are described in the *Rājatarānginī*. The information is couched in mythological terms but that does not mean that even in the 11th century A.D., the scientific connotation of these phenomena might not be known to the people, but that Kalhaṇa (11th century A.D.), a poet, might be ignorant about it.

Regarding the formation of the Kashmir valley it is mentioned (I.20-30) that at first it was occupied by a very large lake called Satisara. During the *vaivasvata manvantara*, Prajāpati Kaśyapa breached this reservoir with the help of the gods Dṛhiṇa, Upendra, and Rudra. The lake was drained away and thus Kashmir *Maṇḍala* was formed. It is wellknown that the flow of rivers within the Himalayan ranges gets many times obstructed because of the natural bunds formed across the river either due to the formation of ice or due to the large slips (avalanches) of the hill slopes, the material of which gets deposited in the river bed. There is a likelihood that a large lake called Satisara might have developed because of the natural obstructions formed across the bed of the river Vitastā. Such instances are mentioned in the treatise as well and are described later in the paragraph on irrigation. When this natural obstruction was cleared manually, as stated above, a large tract of land was made available. The Kashmir valley, because of the great fertility of this lacustrine deposit, soon attracted a large population. The Kashmir valley is within the Himalayan ranges, and it is naturally surrounded on all sides by high mountain ranges which serve as *prākāra* (walls) and protects the whole of Kashmir, making it safe against invasion by outside powers. This was another attraction for its occupation.

It is stated in *tarāṅga* IV (*śloka* 480-490) that sage Kaśyapa had also discovered the once vanished river Vitastā in Kashmir. This again could be explained by the fact that the river Vitastā had almost vanished into its own lake called Satisara. The river was discovered again when its flow from the lake was revived by the removal of the natural obstruction. In the *Rgveda* it is mentioned

many times that Indra had removed the obstructions of rivers and let them flow along their courses (*R.V.* VII 18.8, VII 18.9, *etc.*). The formation of the Kashmir country and the rediscovery of the river Vitastā is explained by the poet following this old idea emanating from the Vedas.

A good example of the ancient way of explaining a geomorphological phenomenon in a mythological form is provided by the following account. The river Rembyāra meets the river Vitastā at the confluence called Gambhīra, which is located 4 km from the village Cakradhara. The bed width of this river is nearly 3½ km at the confluence. For a length of almost 11 km the bed of this river is full of boulders. This is a clear case of deposition of sediment by the river because of the decrease in the velocity of its water where it meets another bigger river. The velocity of river water in a mountainous country is very high and the water carries large boulders during floods. When a river meets another river, its velocity decreases considerably and as a consequence it deposits its sediment, largely boulders, near the confluence. The presence of such a large number of boulders for the great length of the river Rembyāra is explained in a mythological story that these boulders were brought by the she-cobra Ramaṇyā who came to help her brother Cobra Suśravasa fighting against King Nara (I.260-270).

In the Himalayan region, the flow of a river gets many times suddenly obstructed by accumulation of materials in the river bed due to large slips along the slopes of the mountains located along its bank and a lake gets formed. Such formation of lake is also explained by a mythological story. It is stated (I.260-270) that Cobra Suśravasa had formed a big tank for his residence. The colour of the water of this tank was as white as milk. This tank (lake) still exists near the source of the river Lidar and it is known as *Seṣanāga*. It is also called as *Suśravasanāg*. The idea of obstructing the flow of a river by a serpent is as old as the Vedas, wherein Vṛtra is said to have obstructed the path of the river Paruṣṇī. The same mythological tradition is used here to explain the formation of a lake.

Large stretches of wind-blown dust of sandy to clayey constitution called loess are found in Kashmir (Krishnan, 1960). Heavy dust storms, as a result of which the atmosphere remains dusty for a prolonged period, are responsible for this phenomenon. This phenomenon of the deposition of loess soil in Kashmir is also explained in mythological terms. It is stated by the author (VII.1340-1350) that before King Lalitāditya (700-736 A.D.) installed the silver idol of Parihāsa Keśava, there used to be a lot of dust in the atmosphere for quite a long time. But after the installation of this idol, the dust in the atmosphere vanished. This phenomenon was attributed to the luminosity of the idol. The poet further states that when in the early 12th century A.D., King Harṣa destroyed this idol, the atmosphere again became full of dust. This dusty atmosphere was said to have remained upto the end of the reign of king Harṣa.

CONSTRUCTION OF TOWN, CITIES AND MONUMENTS

While studying this historical treatise it is noted that almost every king built a town to commemorate the beginning of his reign or to mark an important event in his life like the annihilation of an important foe, performance of a grand sacrifice, *etc.* Sometimes the construction of a town is the only achievement mentioned of a king. Given below are few examples of the construction of towns, cities and monuments which denote the status of advancement in Civil Engineering with the passage of time.

It is stated that king Lava (before c. 1182 B.C. according to Kalhaṇa) had constructed 84 lakh temples of stones. He had also constructed a town called Lolera (I.80-90). Remains of stone temples of such an antiquity are, however, not found in Kashmir.

King Surendra (before c. 1182 B.C.) constructed a city called Soraka. This might be the present day town called Surasa in the Nagoma district, along the bank of the river Saṅgasafeda. He had also constructed two *vihāras* called Narendrabhuvana and Saurasa (I.90-100).

Emperor Aśoka constructed a very large, rich and flourishing city called Śrīnagara. There were 96 lakh houses in this city (I.100-110). This very old city might be the town called Paṇḍethāna—Purāṇādhiṣṭhāna located on the right bank of river Vitastā. This emperor constructed a number of edifices like *stūpas*, *vihāras*, *caityas*, *etc.* as he was a devoted Buddhist. He constructed *stūpas* at Śuṣkalettra (now called Hakalitra) and at Vitastātra (now a village called Vidha-vetura). The *caitya* built in the *vihāra* located in Vitastātra was very tall and its height could not be judged by a mere look at it.

King Jaloka, son of emperor Aśoka also constructed a *vihāra* called Kṛtyakāma (I.140-150). This *vihāra* is the one called as Kitace as quoted by the Chinese traveller Ukong in 750 A.D. It is located in the village Kiṭasoma which is seven kr. from the town Varāhamūla located on the left bank of river Vitastā. These archaeological findings bear testimony to the correctness of the information given by Kalhaṇa.

King Nara or Kinnara (1090 B.C.) had constructed a city called Kinnarapura on the bank of Vitastā. It was a very beautiful and large city. There were many long and wide royal roads, streets and bazaars. There were many gardens and parks (I.200-210). Kinnarapura was located near Vijabhora. The construction of the city along the bank of Vitastā indicates that the practice of taking advantage of the protection of a river around the city, so as to use it as a moat, was probably prevalent from very ancient times in India. It is clearly mentioned (VIII.1051) that the city of Śrīnagara was encircled by the river Vitastā which functioned also as a moat. This city was established, according to Kalhaṇa, before 1182 B.C.

Lalitāditya (700-736 A.D.) had constructed a large and beautiful temple of

Mārtaṇḍa. It was built of stone. It is still standing but is in a very dilapidated condition. This is probably one of the evidences that temples in stones, as large as that of Mārtaṇḍa, used to be constructed in India by 700 A.D. In fact it could be said that where stone was available in abundance it was used for construction of houses *etc.* (even in protohistoric time). It is a case of the availability of material that determined the choice of material for the construction of structures rather than the ignorance about its use. (Sankalia *et al.*, 1969).

Jayāpīḍa was the grandson of King Lalitāditya and he built the city of Jayapura Koṭṭā. It is stated (IV.550-560) that this king had taken the help of Sri Lankans (engineers) for the construction of a large lake. This city was provided with two fortification walls in addition to the moat (formed by way of construction of the lake). The present village Andrakotta (inner fortification) is located as a small island in the lake Sambal. The outer fortification wall was called Dvāravati. This may be called a water fort (*Jaladurga*). The king had constructed a large *vihāra* and established in it three idols of Buddha. In the Andrakotta island remains of a number of old temples have been discovered. It seems that Sri Lankans were famous at that time for their skill in construction of high and long dams so as to form very large lakes. This observation is substantiated from the description of large tanks in the well known historical record of Sri Lanka called *Mahāvamsa* and also from archaeological findings in that country.

Queen Diddā, in the reign of King Nandigupta, (972-973 A.D.) is said to have constructed a fortified town named Kankaṇapura. She not only built 64 large stone temples but also had constructed stone built rampart walls of old temples whose rampart walls were burnt down (VI.300-310). This statement may indicate that before the 9th or 10th century A.D. the rampart walls of temples used to be constructed of wood which might have been available in abundance, and stone rampart walls became popular later as the advantages of stone walls came to be understood. It seems that wood was the predominant material used for the construction of houses and other structures in towns and cities. It is described that during the reign of king Abhimanyu (958-972 A.D.) a fire started at the bazaar near the temple of Tungeśvara and burnt down almost the whole state city. The fire was so widespread and wrought such a destruction of the city that it was thought worthwhile to mention it in this treatise (VI.190-200). Even by the eleventh century A.D. wood was the chief material for the construction of towns as it is stated that King Jayasiṃha had donated wood from the forest, free of charge, to the citizens and thus built a new city (VIII.2390).

King Jayasiṃha, (Kalhaṇa was contemporary to him), had constructed the temples of Vijayeśa Śiva and other gods. These were plastered with lime. These temples were very large and white colour because of lime plaster, and hence looked so beautiful that they were compared with Kailāsa mountain which is covered by snow. This thus marks a further advance in building construction. The use of lime plaster was known in very ancient period—as early as Buddhist time, as many of the *stūpas* containing relics of Buddha were lime plastered. But the

practice of the use of lime plaster for temples seems to have become popular by eleventh century A.D. The king also very wisely made provision of funds so that the monuments constructed by him as well as old monuments could be maintained properly and perpetually. (VIII.2370-2380).

FORTIFICATIONS

It may be noted that circumscribing a city or a town by a rampart wall is quite an ancient tradition in India. The cities of Harappa, Mohenjodaro and others (c. 2350-1750 B.C.) were fortified. This idea of protection was very much entrenched in the mind of people so that while eulogising the Kashmir valley, poet Kalhaṇa emphasized that the valley is naturally fortified by high mountain ranges all around it which act like natural rampart walls.

It has been mentioned earlier that Jayāpīḍa constructed a city with two fortification walls with a moat around them.

The temple of Cakradhara was located 1½ km downstream the town Vijayēśa (now called as Vijabhora). This temple was surrounded by a strong fortification wall. The temple was so old that Emperor Aśoka (3rd century B.C. or before 1182 B.C., according to Kalhaṇa), it is said, rejuvenated it. (I.30-40).

There was a temple dedicated to god Vijayēśvara which was fortified by a mud rampart. Emperor Aśoka had constructed a very large and strong fortification wall of stone (I.100-110), after demolishing the mud rampart.

It is possible to understand the advancement in the art of construction of fortifications around a city or a temple from the above examples. It appears that the earliest fortifications were made of mud walls, which might have been adequate for protection against beasts from jungles and the men of the invading army. The height and width of the walls might have been such that it could not be scaled by men or beasts, and could not be easily breached by light battering rams. A height of four to five meters seems to have been sufficient.

With adequate advancement in the tools for cutting the trees and also in the art of carpentry for building strong wooden stockades, fortification walls of wood started being favoured over those constructed of mud. As wood was available in abundance and very thick logs could be obtained for forming rampart walls (constructed of cribs possibly filled with mud) wooden rampart walls were gradually adopted. In case of temples wooden rampart walls with quite a good decorative effect might also have found favour over mud walls.

By about 10th or 11th century B.C. use of stone masonry for construction of fortification walls might have begun. The art of digging out large blocks of stones was well developed by this time and must have reached a mature stage by the time of Emperor Aśoka. The advantages of the stone wall for fortification over that of mud or wood were obvious, particularly with the advance in the knowledge of incendiary material and also the development of war machines

(*Ulhāta yantras*) to throw big stones inside the town over and across the rampart walls. Mud walls would give way under the force of heavy battering rams. The wooden wall could easily be burnt. On the other hand, stone masonry could be very strong and free from these drawbacks. Use of heavy stones, even without mortar, for the construction of rampart walls could make the walls unbreakable under the force of even very heavy battering rams. The walls could be constructed quite high, say upto 10 to 15 metres, so that big stones and boulders could not be thrown across them even with *Ulhāta yantra*.

It seems, however, that at least for temples, the practice of wooden fortification was not completely given up; as it is mentioned that when Harṣamitra lost the battle with Bhikṣācāra, he entered, along with his army, the famous fortified temple of Cakradhara Viṣṇu. This temple was fortified with a strong wooden stockade. It was also provided with very strong impregnable doors. Harṣamitra thus got a temporary protection. But however strong may be the wooden stockade, methods to burn it were developed by then, and this is how the army of Harṣamitra, hidden inside the fortification, was annihilated (VIII.970-980).

ROADS AND OTHER FORMS OF TRANSPORT

The poet mentions (III.220-230) that when Mātr̥gupta was travelling in Kashmir, his journey was very comfortable as the passes were not very steep and there were rest houses along the road. It appears that the roads in the valley were not only aligned with intelligence and imagination but they were also properly maintained and well provided with rest houses, located along the road possibly at a distance of one day's ride, for the comfort of travellers. Mātr̥gupta was stated to be a commissary of king Harṣavikrama who reigned in the year 500 A.D. as ascertained from the travels of Huentasang. Thus it may be stated that roads in Kashmir were in good shape by 500 A.D. In *taraṅga* V (130-140), it is mentioned that king Śaṅkara crossed the border of his kingdom to conquer the world. His army consisted of nine lakh troops, one lakh cavalry men and three hundred elephants. It is rather difficult to imagine that the condition of the roads was good enough and their width large enough to permit the transport of such a large army with any convenience.

It is stated that king Pravarasena (80 or 550 A.D.) constructed a bridge called Bṛhatsetu across the river Vitastā and it is further stated that the practice of constructing bridges started from his time (III.350-360).

Khanka, Śatrughna and Mālava, ministers of the king Bālāditya (III.480-490) had constructed many bridges. There are many mention of bridges throughout the *Rājatarāṅginī* and most of them are in *taraṅgas* VII and VIII, indicating that the art of building of bridges was developed in India from 1000 A.D. (VII.900-910; VII.1070-1080, VII.1560-1570; a boat bridge is mentioned in VII.1540-1550; hanging bridge or rope bridge is mentioned in VIII.400-410;

bridge on Vitastā is mentioned in VIII.710-730 ; VIII.1050-1070 ; VIII.2409 ; VIII.2420-2430 ; VIII.2890-2900). It seems that a number of bridges were constructed across the river Vitastā in the city of Srīnagara. At least two bridges are mentioned in VIII.930-940. Two (probably) additional bridges over Vitastā in this city are further mentioned ; a bridge near Makṣika Svāmī and another was called Bṛhatsetu are also mentioned (VIII.1171).

Construction of boat bridges seems to be the usual procedure to cross a river by the army, specially if a bridge was not already existing at the crossing. It is stated (VIII.1499-1501) that when it was found that the river Gambhīrā could not be crossed as there was no bridge, a boat bridge was constructed and the army crossed the river. It seems that by the 11th century A.D., construction of boat bridges was a common practice.

The construction of a culvert across the river might have been known. It is mentioned that at Kaśyapāgāra, where the river Vitastā turned to flow towards the east, a bridge was constructed so that the river could be crossed by cattle (VIII.3350-3360). This seems to be a submersible bridge, say a culvert. It, therefore, seems that bridges made of boats, masonry as well as of ropes used to be constructed not only across nullahs and small rivers but also across large rivers like Gambīrā and Vitastā.

IRRIGATION

King Suvarṇa, son of King Godhara had constructed a canal called Suvarṇa Maṇikulyā (Golden beaded Canal) in the Karala (I.90-100). According to Kalhaṇa, this king reigned much before 1182 B.C. The remains of this canal are still to be found. It was taken out from river Viśokā and was quite big. It started from the village Laragu. Karala is a taluka now called Jainpura and is a part of Andavina district.

King Jaloka, son of Emperor Aśoka, used to take his daily bath in *Sodara* tank (*tīrtha*), although it was located quite afar from his palace. It is said that once this king could not go to the holy tank and was in a sorrowful mood. At that time a small nullah started flowing nearby. The taste, colour, *etc.* of the water of the nullah was identical with those of the *Sodara* tank water and the king, after bathing in this water, felt as cleansed as he used to feel when taking bath in *Sodara* tank. In order to check that the source of water of the newly formed nullah was *Sodara* tank the king left a golden pot, its open end being sealed, in the tank. He found that after 2½ days the golden pot arrived at the nullah, indicating that *Sodara* tank indeed was the source of the water of the nullah (I.120-130). This method of identifying the underground source of water by placing a floating object, was quite common as it is mentioned in many folklores.

King Dāmodara II constructed a very long and high dam called Guḍḍasetu with the intention of supplying water to a place called Dāmodarasūda (I.150-

160). Dāmodarasūda was a high level plateau, south of Śrīnagara and was about 30 meters higher relative to Guḍḍasetu. It appears that, although mentioned as an accomplished fact, either the scheme did not materialise or the structures have been buried under the soil deposit, as at present one could not discover any remains of any dam at the said locality *i.e.* near the village Guḍḍasūda. It is further stated that the king had also constructed a number of large stone masonry dams so as to protect the valley from sudden floods.

King Lalitāditya (700-736 B.C.) arranged lift irrigation so that the water of the river Vitastā could be supplied to many towns that were located at a level above that of Vitastā (IV.190-200). This might have been arranged by utilizing series of *shadufs*.

Lalitāditya is said to have formed rivers which were called Kuntavāhinīs (IV.300-310). It seems that the king constructed a number of diversion canals which were called rivers. The width of the diversion canals was generally kept very large to increase their capacity to hold water. This helped to collect very large quantities of water in the canal during the limited period of high level river flow during floods. This water collected in canals would then be used in fair weather season. This characteristic of these canals might have led to their being called rivers.

During the reign of the king Avantivarmā (855-883 A.D.) a man called Suyya had shown extraordinary talent in the understanding of hydrodynamics as could be observed from the measures he had taken for protecting the valley from floods, and increasing the yield of crop by providing adequate drainage and irrigation facilities to the fields. The methods followed by him were quite advanced as described by Kalhaṇa (V.80-120).

It is stated that during and even before the reign of king Avantivarmā almost all the rivers, nullahs, as well as the lakes like Mahāpadma were flowing full and large tracks of land were almost always under water or were having ground water table very near the ground surface. This possibly happened due to the increase in the temperature of the atmosphere and consequent melting of snow of the Himalayan mountains. This situation led to a paucity of agricultural produce. During his reign the king Lalitāditya, arranged to drain away the water. But because of the carelessness of the subsequent kings, a wet famine condition developed by the time of king Avantivarmā's reign.

As already stated earlier, the flow of the river Vitastā was obstructed at many places because of avalanches and formation of natural dams of stones across the river. This is given as one of the reasons of the high level of the ground water table, and flooding of the country in general. Suyya had arranged to remove the accumulated stones from the bed of the river and the water of Vitastā started flowing freely, consequently, this led to the lowering in the level of the ground water table and the low lying areas also emerged above the water level and became dry. Further, he constructed long circular bunds around the towns and cities so that during the floods they might not be inundated.

Suyya had constructed a number of diversion canals from Vitastā so that the flood water would flow into these canals avoiding the flooding of valuable agricultural land. He, in addition, constructed long stone masonry dams, some of them 35 km in length, across Vitastā. Canals were taken out from both the banks of the river. This arrangement not only reduced the destruction of valuable land, as the construction of large reservoirs led to an increased flood absorption capacity, but also made water available for irrigation in fair weather season. This method of flood protection and irrigation of land is quite advanced even for modern times. It is further stated that Suyya constructed a dam across the lake Mahāpadma, with provision of outlets so that the water may collect in the lake during floods, and could be released to the river Vitastā whenever required. Thus Suyya not only lowered the ground water table but controlled the flood of the river by constructing inundation canals, large reservoirs and irrigation canals. The poet sang the eulogy of Suyya saying that his feat of taming Vitastā could be compared to that of a snake charmer who controls mighty snakes. The poet further added that the control of Vitastā not only led to the availability of large tracks of dry land but that the population was not required to depend only on rain water, as ample quantity of water was available due to adequate irrigation system.

Suyya had shown great understanding regarding irrigation water management. He conducted experiments to determine the optimum period between two feedings of canal water for the type of soil available in the country and arranged to supply irrigation water by turn at regular intervals— a method the Maharashtra Government is thinking to adopt. This account shows that as early as 9th century A.D. Indian people studied the problem of economical distribution of canal water for irrigation purposes and found a successful solution of irrigation water management. The best evidence of successful utilization of irrigation water is given by the poet himself (V.110-120) ; the cost of one Khāri (≈ 80 kg) of rice, which was 200 dinars before, decreased to 36 dinars after the provision of irrigation and drainage of the land.

It has been stated that a number of stone masonry dams were constructed by Suyya. It appears that building of stone masonry dams was a very common thing at the time of poet Kalhaṇa (11th century A.D.) as he uses it in a simile. He mentions (VI.270-280) that the *vajra*, thunder bolt of Indra, cannot be destroyed by weapons made of any metal, similarly water cannot breach a stone masonry dam, but there is nothing which cannot be broken by a lie.

King Harṣa (first quarter century of 1200 A.D.) constructed a lake called Pampā which occupied a very large area (VII.930-940). This is probably the same as the lake now called Pambasara. The construction of canals for supplying water to garden land and parks was also a common practice by this time as mentioned in VIII.3360. The importance of dams and canals to bring prosperity to the country was well entrenched in the minds of the people by now as it is stated by the poet (VIII.2409 ; VIII.2420-2430) that the king and his ministers constructed bridges and bunds so as to bring prosperity to the country.

Well irrigation was also known as persian wheels, handwheels, pulleys, *etc.* are mentioned (VII.1230-1240). The persian wheel is mentioned (VIII.2960-2970) indicating its function and arrangement. The above description of the state irrigation in Kashmir by the ninth century A.D. as given in *Rājatarāṅgiṇī* indicates the advanced knowledge of the people in this field of engineering. It is rather unfortunate that one has to collect this information from the historical treatise rather than from old scientific treatise on irrigation management. Such treatise must have been written at that period as seen from its advanced nature and it is very necessary to hunt for them and bring them to light.

WAR IMPLEMENTS

The *Rājatarāṅgiṇī* gives information of many battles and wars between the kings and their relatives and other kings from different countries. But there is not much information regarding the implements used for fighting. The one war machine that is mentioned is *Ulhāta yantra*, which was used for throwing big stones with a force from the ground towards the warriors fighting from the top of fort walls. It seems to be so common by the time of Kalhaṇa (11th century A.D.) that once he had used its action as a simile. He mentions (I.360-370) that king Yudhiṣṭhira could not restore order in his already disorderly kingdom as a stone released from the *yantra* cannot be moved back. The *Ulhāta yantra* is also mentioned in VIII.1670-1680 ; VIII.2530.

It is mentioned that Śrīnagara city was burnt down during the reign of King Utkarṣa (11th century A.D.) by his son Vijayamalla. For this purpose, soldiers placed pieces of clothes soaked with oil on tips of arrows, lighted them and sent the arrows flying towards the buildings. This is, thus, another implement for bringing destruction to the invaded city by using the so called incendiary arrows (VI.760-770). It is also mentioned (VII.980-990) that arrows with iron shafts (*nārāca* arrows) were used for this purpose. Heavy arrows were used for two reasons—one was that the aim was improved and the other was that they could be thrown to greater heights, as a heavy bow was used to throw them to tall buildings or to longer distance.

MISCELLANIA

King Lalitāditya is said to have established the idol of god Narasiṃha in the kingdom of women. He made use of magnets so that this idol could stand free of any support and also could be moved up and down as required (IV.180-190). It seems that quite a good knowledge of magnetism had been acquired by the 8th century so that an idol of a deity without the danger of desecration and quite artistically, could be installed free of any support.

This very king had got forged a golden idol, weighing 840 kg. of god Śrīmukteśvara and a silver idol of god Parihāsa Keśava which was four times heavier than the golden idol. He had, in addition, forged a great idol of Buddha

in copper, which was 16 times heavier than the silver idol. It was very tall. It is further stated that the king constructed suitable *caityas* to accommodate these idols (VI.200-210). The description of very tall and large idols of Lord Buddha occurs many times in the travels records of Huent Sang and it seems that much before 8th century A.D. the art of forging heavy idols was perfected in India. It is worthwhile to search for the literature in which information on forging procedure is given.

A ball called *tr̥ṇa-maṇi* is mentioned (VIII.2820-2830). It is stated that this ball attracted (very light) materials like grass. It seems that the ball was made of amber, which when rubbed develops static electricity and attracts light objects.

Information regarding maintenance of forest and means to arrest the spread of forest fire is given in a statement that forest fire is arrested from spreading by a mountain nullah (VIII.2840-2850).

REMARKS

It could be understood from the facts and their discussion given above that quite a great advance was made by Indians (Kashmiris) in house construction and town planning. The practice of construction of houses of stone was in vogue as early as 700 B.C. as revealed from the remains of the Mārtaṇḍa temple. The advances in the engineering aspects of irrigation were quite astounding and the methods utilised for flood protection, drainage and irrigation of land were quite advanced. The *vārābandī* system which is being introduced in Maharashtra now was actually followed in the 8th century A.D. in Kashmir. The proficiency in forging very large metal statues which were as heavy as 54 tonnes was also astonishing. It may, however, be supposed that an understanding of the geomorphology of the country was not given much attention to, and there was a tendency to explain these in mythological terms.

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