Global Journal of Researches in Engineering
Industrial Engineering
Volume 13 Issue 4 Version 1.0 Year 2013
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 Print ISSN:0975-5861

Ergonomic Evaluation of Tasks Performed by Workers in Manual Brick Kilns in Karnataka, India

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Abstract - Brick industry in India is the second largest brick producer in the world after China. The industry is one of the largest employment generating industries employing millions of people. The present study focuses on the brick industries located in North Karnataka, India, where about 1500 brick kilns are operating employing thousands of workers. The main aim of this study is to investigate the self reported Workrelated Musculoskeletal Disorders (WRMSD) experienced by the workers during the raw brick making activities and to analyze the causes of discomfort related to various postures adopted by the workers. Sixty workers from 6 raw brick making units were randomly selected and a detailed work related musculoskeletal pain/discomfort were analyzed in different activities using the revised Nordic Questionnaire. All the selected workers had given their responses, which were analyzed. Majority of the respondents were feeling pain and discomfort in different body parts. It was also observed that the workers worked continuously in awkward postures during certain raw brick making activities. Consequently they may suffer from discomfort in different parts of the body. Postural analysis using RULA and REBA methods indicate that different parts of the body are vulnerable to injury and musculoskeletal disorders and require immediate ergonomics intervention.

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GJRE-G Classification : *FOR Code: 670000*

Strictly as per the compliance and regulations of :

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Abstract - Brick industry in India is the second largest brick producer in the world after China. The industry is one of the largest employment generating industries employing millions of people. The present study focuses on the brick industries located in North Karnataka, India, where about 1500 brick kilns are operating employing thousands of workers. The main aim of this study is to investigate the self reported Work-related Musculoskeletal Disorders (WRMSD) experienced by the workers during the raw brick making activities and to analyze the causes of discomfort related to various postures adopted by the workers. Sixty workers from 6 raw brick making units were randomly selected and a detailed work related musculoskeletal pain/discomfort were analyzed in different activities using the revised Nordic Questionnaire. All the selected workers had given their responses, which were analyzed. Majority of the respondents were feeling pain and discomfort in different body parts. It was also observed that the workers worked continuously in awkward postures during certain raw brick making activities. Consequently they may suffer from discomfort in different parts of the body. Postural analysis using RULA and REBA methods indicate that different parts of the body are vulnerable to injury and musculoskeletal disorders and require immediate ergonomics intervention.

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I. Introduction

Work-related Musculoskeletal Disorders (WMSDs) have become a major problem in many industrialized countries including India. Manual brick manufacturing in India is currently an extremely hazardous occupation. In the developed countries some mechanization was introduced but various studies show that the workers working in the brick manufacturing units suffer from musculoskeletal problems (Cook 1996, Chung and Kee, 2000; Trevelyan and Haslani, 2001).

Notwithstanding the technological advances, a large number of workers perform heavy manual material handling (MMH) jobs in developing countries, especially in the unorganized sectors. Studies from developing countries like India show that these workers suffer from assorted health problems due to awkward postures and carrying heavy loads (Mukhopadhyay, 2008; Sett and Sahu, 2008).

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The ergonomics of brick kiln involves the interaction of personal factors such as fatigue, fitness, age and experience and circumstantial factors such as work organization, work schedule, work load, factory layout, furniture, equipment and psychological support within the work team, which combine to affect the efficiency of work and working life. Analysis of the interaction of these factors influencing physical strain and cognitive strain is essential to improve the working conditions.(Manoharan 2012) The postures adopted by the workers in their working place depends upon the type of work, the design of the work place, personal characteristics, the tools required to perform the particular work and also the duration and frequency of the work cycle (Bridger, 1995). So, various techniques have been reported for postural analyses to identify the stress during different phases of work (Colombini et al., 1985).

a) The brick manufacturing scenario in India

Brick kiln, being a small scale industry has a very important role to play in Indian economy. Brick is one of the most important building material used in construction in India. The Indian brick industry, the second largest producer of brick in the world, is next to that of china. The brick industry in India falls into the small scale and unorganized sector with more than 100,000 brick kilns spread throughout the country, and each unit manufactures between 1 lakh to 1 million bricks every year. (Saidapur, 2012). There are around 1500 brick-kiln units operating in the north Karnataka State. These brick-kilns represent one of the major small-scale industries, which fulfill the ever growing demand of urban expansion.

In unorganized sectors, the workers are recruited temporarily on a seasonal basis for the entire season of brick making. The workers have no experience and they are not provided with any training. Therefore, they do not have any previous knowledge about unsafe acts and hazards related to this work, awkward postures, or they simply ignore the safe working process. Manual material handling (MMH) is the cheapest solution in developing countries (Maiti, 2008), so most of the brick manufacturing units in India perform the task of MMH.

The workers are recruited by employers on a seasonal basis, mainly from November to May. These workers come from nearby villages from the same or

sometimes different states of India. No work occurs during India's monsoon season (June to September). They then go back to their villages and engage themselves in some other work like agriculture or remain unemployed.

Jobs in brick kilns involve a very wide range of physical actions from postures and positions that may not be ideal and could place workers at risk for accidents and injuries. The common jobs in brick kilns comprises of pushing, pulling, bending, reaching, stretching, lifting, lowering, sitting, standing, walking and carrying, mining/rimming of clay, preparation of clay, molding of clay, drying of bricks, burning of bricks and the final product i.e. the brick. This stressful situation can be made worse by physical discomforts in the workplace and cause MSD's. The prolonged stresses and strains caused during the various activities with different load conditions is a cause for Work Related MSD's.

This exposure involves high physical workload which is assessed through the analysis of posture, movement, and cumulative load over time or through indirect approach of questionnaires or checklists. This paper focuses on assessment of physical risk factors among workers engaged in different processes of brick manufacturing through discomfort/pain that are experienced during job hours using interviewer-administered structured questionnaire, and postural analysis using the techniques of RULA and REBA.

II. Materials and Methods

The study was conducted on 60 workers (30 male and 30 female) selected randomly engaged in 6 different brick fields of North Karnataka. The workers with at least one year of experience were chosen. The workers carried out the following activities: (i) digging and crushing clay, (ii) wetting clay, (iii) mixing clay, (iv)loading and pushing the trolley or wheelbarrow, (v) molding raw bricks, (vi) arranging bricks to dry, (vii) moving the dried bricks to kiln for burning (viii) loading bricks on to the truck, tractor, and cycle or on others. To carry out such activities, workers most often have to adopt awkward postures for a longer period i.e. near about 11 hours that result in musculoskeletal pain/discomfort affecting different body parts.

a) Nordic Musculoskeletal Disorder Questionnaire

A modified Nordic Musculoskeletal Disorder Questionnaire was given to the workers. The questionnaire consisted of a series of objective questions with yes or no response and some were in multiple choice questions. To investigate discomfort, it included detailed questions on work-related pain in different body parts. Work-related pain/discomfort was reported in 12 month, one month and prevalence in 7 days. The participants were interviewed about any kind of discomfort affecting different body parts during every activity associated with raw brick making task.

b) Postural Analysis

Working postures were evaluated directly by visual observation as well as indirectly by using a still photography and video of the different activities performed by the workers. The photographs and video were later used to identify the different categories of work postures prone to injury such as bending, twisting, tilting the head forward. These were later used to evaluate the risk level by the techniques RULA and REBA.

c) Rapid Upper Limb Assessment (RULA)

RULA is a quick survey method for use in ergonomic investigations of workplaces where MSD's are reported (McAtamney, L. and Corlett 1993). It is a screening tool that assesses biomechanical and postural loading on the body. It focuses on the neck, trunk and upper limbs, and is ideal for sedentary workers. It is a simple, quick and easy to complete. RULA scores indicate the level of intervention required to reduce MSD risks. It compliments other ergonomic methods. RULA assesses the posture, force and movement associated with sedentary tasks such tasks include computer tasks, manufacturing or retail tasks where the worker is seated or standing without moving about. This tool requires no special equipment in providing a quick assessment of postures of the neck, trunk and upper limbs along with muscle function and the external loads experienced by the body. A coding system is used to generate an action list which indicates the level of intervention required to reduce the risks of injury due to physical loading on the operator (Table 1).

d) Rapid Entire Body Assessment (REBA)

REBA (Rapid Entire Body Assessment) was developed by (Hignett, S. and Mc Atamney, 2000), to provide a quick and easy observational postural analysis tool for whole activities (static and dynamic) giving musculoskeletal risk action level. The development of REBA is aimed to divide the body into segments to be coded individually with reference to movement planes. It provides a scoring system for muscle activity caused by static, dynamic, rapid changing or unstable postures. It reflects that coupling is important in handling of the loads but may not always be via the hands. It also gives an action level with an indication of urgency. This method was specifically developed to be useful for assessing MSD risks/working postures found in healthcare and other service industries. However, it can be used to assess a variety of tasks, in any setting, where: the whole body is being used, the posture is static, dynamic, rapidly changing, or unstable, or animate or inanimate loads are being handled either frequently or infrequently. (Table 1)

Table 1 : Classification of Risks according to postural score

RULA		REBA		
Rula Score	Action Required	Action level (Risk level)	REBA Score	Corrective Measure
1-2	Acceptable	0 (Negligible)	1	None necessary
3-4	Change may be necessary	1 (Low)	2-3	May be necessary
5-6	Change necessary soon	2 (Medium)	4-7	Necessary
7	Change immediately	3 (High)	8-10	Necessary soon
		4 (Very High)	11-15	Necessary NOW

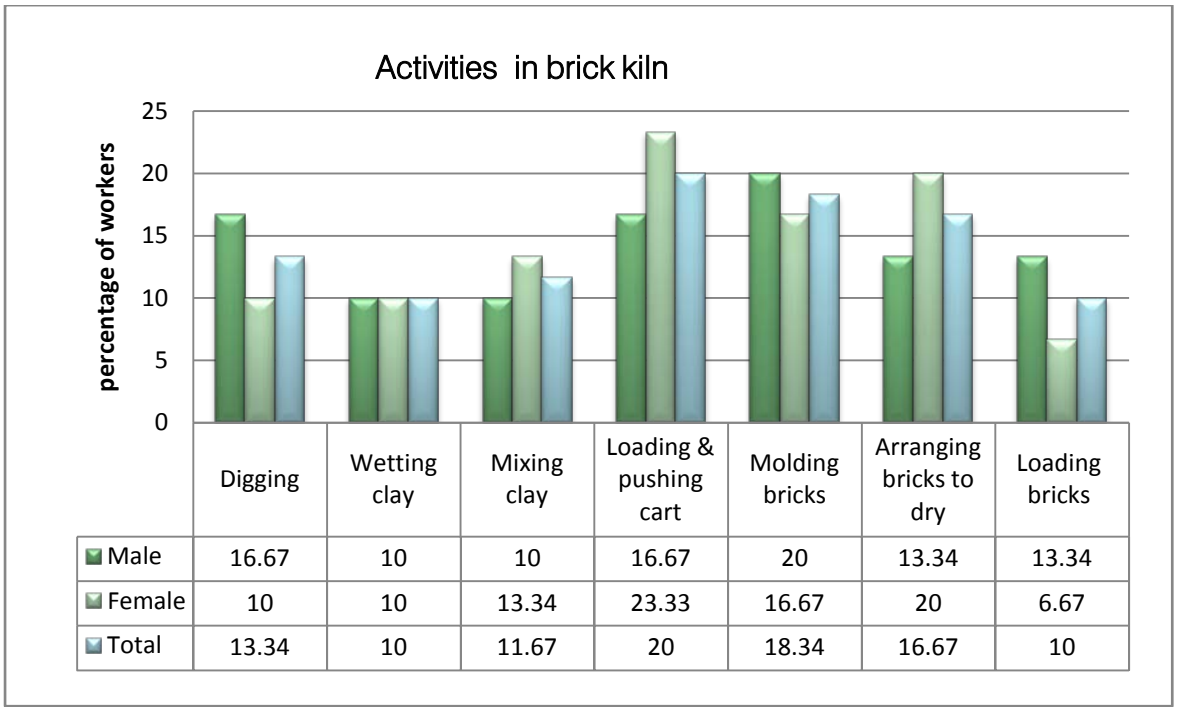
III. Results and Discussion

a) Work Process in Brick Kilns

The brick kilns located in north Karnataka were of open type as shown in Appendix A. The workers usually start work at 6 am in the morning and work till 11 am. They take rest and start work after lunch at 3 pm and work till 6 pm. The workers take rest in between for about 10-15 minutes under a shade of tree or a thatched roof hut. A group of 15-25 workers work in a brick kiln producing about 100,000 bricks.

There were two main steps observed in brick making. In the first step a brick is manufactured from mud with the help of a mould. The bricks are then dried in sunlight for 2-3 days. In the second stage the dried bricks are taken to the kiln and stacked on top of it for further curing and hardening. The bricks are burnt for about a week and then removed from the kiln and are ready to use in construction. Manual brick making in this part of the country is based on demand.

The different activities of workers in a brick kiln (figure 1) shows that 20% of workers are involved in loading of mud into a cart, pushing the cart and unloading the mud at the molding area. Molding activity involves 18.34% of workers and they work continuously until a batch of bricks is produced. About 23.3% of workers carryout the digging and wetting of clay. For loading and unloading the bricks on to kilns 10% of workers are involved. In most of the kilns, the workers work in groups and each group performs certain activities like a group of workers doing the digging and wetting clay activity do not mold the bricks.



	Digging	Wetting clay	Mixing clay	Loading & pushing cart	Molding bricks	Arranging bricks to dry	Loading bricks
Male	16.67	10	10	16.67	20	13.34	13.34
Female	10	10	13.34	23.33	16.67	20	6.67
Total	13.34	10	11.67	20	18.34	16.67	10

Figure 1 : Different activities in a brick kiln and the %age of workers doing each activity

b) Physical Characteristics of the Workers

The physical characteristics and experience of the workers was noted and shown in Table 2. The mean height of the workers were found to be 158 cms and the mean age was 26.4 years. The mean Body Mass Index (BMI), a measure of obesity and defined as weight in kilograms divided by height in metres squared was 21.92 kg/m^2 with a range of 17.2 and 33.6 kg/m^2. Using the criteria for obesity that for non-obese person, the BMI should lie between 18.5 and 24.9kg/m^2, 25 and

29.9 kg/m^2 as overweight, 30 and 39.9 kg/m^2 as moderate obese and more than 40kg/m^2 as extremely obese (Singh et.al., 2009),some of the female workers were found to be underweight while none was obese.

Table 2 : Physical characteristics of the workers

Variables	Mean (SD)
Age (yr)	26.4 (± 9.5)
Height (cm)	158.2 (± 11.3)
Weight (kg)	41.9 (± 9.7)
Years of Experience	3.7 (± 8.6)
Duration of work per day (hours)	9.5 (± 1.8)
Body mass index (BMI) (Kg/m^2)	21.92 (±3.35)

c) Discomfort and pain (Nordic Musculoskeletal Disorder Questionnaire)

The work related musculoskeletal disorders and the body pain perceived by the workers was determined by administering the standard Nordic musculoskeletal disorder questionnaire. The responses given by the workers were analyzed. The workers complained about the activities causing pain and discomfort. It was reported that 90% of the respondents complained pain in digging and crushing activities, while 72 % of workers said that the wetting of clay caused pain. All the workers who responded suffered from pain and discomfort in activities like mixing of clay, carrying in a trolley and pushing the trolley. Nearly 81% of workers felt pain during the molding of bricks. 28% of respondents experienced pain while arranging the bricks for drying. Another 88% of workers reported significant pain and discomfort while loading the bricks on to truck or tractor.

Table 3 : Discomfort feeling at different body parts among the workers (n=60)

Different body parts	No. of affected workers (%)		
	Male	Female	Total
Neck	19 (64)	17 (57)	36 (60)
Shoulder	22 (73)	20 (67)	42 (70)
Elbows	24 (80)	23 (76)	47 (78.33)
Wrist/hand	23 (76)	21(70)	44 (73.33)
Upper back	24 (80)	22 (74)	46 (76.67)
Lower back	26 (87)	23 (76)	49 (81.66)
Hips/thighs	18 (60)	20 (67)	38 (63.33)
Knees	21 (70)	20 (67)	41 (68.33)
Ankle/feet	25 (83.33)	26 (86.66)	51 (85)

Table 3 shows the pain and discomfort in different body parts and the number of workers affected, both male and female. It can be seen that 81.66% complain of low back pain and 76.67% complain of upper back pain. It is clear that brick molders have more pain in the back because they sit continuously in the awkward posture to mold the bricks. Almost 73% males and 67% females feel pain in the shoulders. Regarding pain and discomfort in the neck 60% reported pain. The workers involved in loading, unloading and carrying experience pain in the shoulder, neck, hand/wrist and elbows. Concerning pain in elbows 80% males and 76% females reported pain. On the other hand 73% respondents, 76% males and 70% females complained pain in the hand/wrists whereas 63% respondents reported pain in hips/thighs. Studies further show that 85% of respondents experienced pain in the ankle/feet, while 68% reported pain and discomfort in the knees.

d) Measurement of Environmental Parameters

The workers in brick kilns are exposed to heat and they work in direct sunlight. The temperatures in north Karnataka are quite high during the summer. The temperature were measured by using a whirling Psychrometer to record the Dry and Wet Bulb Temperature. The measurements were taken every 2 hours and the mean was calculated. The mean Dry Bulb temperature was 39.80 C (±0.37), and the Wet Bulb temperature was 29.70 C (±0.67). The Globe temperature was recorded as 43.90 C (±1.39).

e) Postural Analysis

The postural analysis of the workers while performing different activities in brick making task were observed and each posture was identified according to the risk involved. the position of the back, upper limbs, and lower limbs i.e. arms and legs as well as load or force used in carrying out the activities were considered for the analysis of posture. The postures adapted by the workers in digging clay, crushing clay, wetting clay, mixing clay, loading wheel barrow, molding raw bricks, arranging bricks to dry and loading bricks on the truck were carefully analyzed. It was found that most of the postures involve bending, twisting, standing or sitting in squatting position. The postures were analyzed using the RULA and REBA techniques. In Table 4 the total postural analysis for the different activities in brick making is represented. In almost all the activities, RULA posture scores are 7 indicating a postural change is needed immediately as the working postures are vulnerable to risks and warrant ergonomic intervention. REBA posture codes indicate that the postures for digging and molding bricks demands immediate attention with a score of 10 to 13. Other postures are also at high risk with a score of 9-10 and require intervention soon.

Table 4 : Maximum RULA and REBA scores for different postures

Posture and Activities	RULA Score	Action level RULA	REBA Score	Risk level REBA	Maximum discomfort in body parts
Digging	7	4	10	High	Low back, Upper back
Wetting and mixing clay	7	4	9	High	Low back, Shoulders
Carrying mud by pushing	7	4	9	High	Low back
Molding bricks	7	4	10-13	High to very high	Legs, low back,
Arranging bricks for drying	6-7	3-4	9-10	High	Low back, neck, shoulders
Loading and unloading	6,7	3,4	7,10	Medium, high	Low back, shoulders, upper back

IV. Conclusion

Manual brick manufacturing in open type of kilns in India is currently an hazardous occupation. There are numerous risks and hazards associated with working in high ambient temperature, working with manual load lifting and awkward postures in which the workers are engaged for long periods. As the workers continuously work in bent or stressful postures, they suffer from discomfort and pain in different parts of the body. The feeling of pain and discomfort is aggravated if the stressful postures are maintained for a long period. Postural analysis using RULA and REBA indicated that most of the postures were vulnerable to work related musculoskeletal disorders and this demands an immediate ergonomics intervention.

The relative duration of working in ambient temperatures exposed to sunlight was critical and it effects the physiological parameters well above the normal value. The external heat of the environment possibly was an important factor adding to the stress level of the workers. This was further substantiated by a increase in heat related symptoms and heat stroke.

The workers experienced injuries in different body parts due to the work process and management/owners inaction in providing safe work environment. There were no personal protective devices to wear, so this was a significant issue in the injuries sustained. The accidents at brick making sites included slips or falls, falls from height, cuts and burns. Surprisingly a few number of snake/scorpion bites were reported at some of the sites. The workers took shelter under a tree or a thatched roof hut during the periods of rest. Drinking water was made available through the tube wells but most of the sites lack proper sanitation facilities. In some sites medical facility was provided by the owners in case of an accident or injury. Most of the male workers were smokers or had habits of tobacco eating. At the end of the day a majority of the workers drink the locally available liquor to get relieved from the stress. Because of the economic conditions, unemployment, and illiteracy these workers are compelled to work under poor working conditions and follow unsafe practices. Sometimes the workers are exploited by the owners of the brick kilns due to unawareness of the legislations or labor laws on the part of the workers.

V. Recommendations

The brick kilns need a well designed comprehensive ergonomics plan and the necessary resources to support the same in order to improve the prevention of WRMSD's, health risks and improve the working conditions and productivity of the workers. Some of the improvements may be in the following directions:

a) Implement a continuous training programme so that each worker becomes aware of the relevant factors concerning postures/discomfort.
b) Improve the workplace and equipment by making minor changes to prevent awkward postures.
c) Considering anthropometry to determine minimum and maximum height to avoid bending and twisting.
d) Design of trolleys and truck for transportation of bricks and/or raw materials
e) Better organize the workplace layout to minimize movements, twisting and asymmetrical lifting or lowering.
f) Limit the height of brick stacking to avoid movements above the shoulder height
g) Various guidelines and measures should be formulated to prevent MSD's.
h) Illiteracy and unawareness emerged as the major constraints regarding workers involvement in different activities and adopting awkward postures.

Hence the role of the owners, developmental organizations,and ergonomists in educating the workers becomes more prominent.

VI. Acknowlwdgement

The authors express sincere gratitude to the owners of brick kilns and the workers for their cooperation and help during the completion of this study

References Références Referencias

1. Bridger, R.S., 1995. Introduction to Ergonomics, (Mc Graw-Hill Book Co.), Singapore.
2. Chung, M. K. and Kee, D., 2000. 'Evaluation of lifting tasks frequently performed during brick manufacturing processes using NIOH lifting equations', *International Journal of Industrial Ergonomics*, 25(2), 423-433.
3. Colombini, D., Occhipinti, E., Molteni, G., Grieco, A., Pedotti, A., Boccardi, S., Frigo, S. and Menoni, O.1985. 'Posture analyses', *Ergonomics*, 28(1), 275-284.
4. Cook, T. M., Rosecrance, J. C. and Zimmermann, C. L., 1996. 'Work-related musculoskeletal disorders in brick laying : a symptom and job factors survey and guidelines for improvements', *Applied Occupational and Environmental Hygiene,* 11(6), 1335-1339.
5. Mc Atamney, L. and Corlett, E. N., RULA: a survey method for the investigation of work related upper limb disorders. *Applied Ergonomics*,24,1993, 91-99
6. Maiti, R., 2008. 'Work load assessment in building construction related activities in India', *Applied Ergonomics*, 39, 754-765.
7. Manoharan. P.K, Singh. B.K, Sanjay Kumar Jha, Ergonomics investigation using Psycho-physiological study for brick kilns' in Jharkhand, *International journal of Environmental Sciences*, Volume 2, No 3, 2012,pp 1484-1491.
8. Mukhopadhay P. Risk factors in manual brick manufacturing in India. *HFESA Journal, Ergonomics Australia* 2008; 22(1):16–25.
9. Singh, D., Park W., and Levy, M. S., Obesity does not reduce maximum acceptable weights of lift. *Applied Ergonomics,* vol. 40, pp. 1– 7, 2009.
10. Sharnappa Saidapur- Informal Brick Industry in the North Karnataka- Flourish or Perish, *Arth Prabhand: A Journal of Economics and Management,* Vol.1 Issue 8, November 2012.
11. Sett, M. and Sahu, S., 2008. 'Ergonomic study on female workers in manual brick manufacturing units in West Bengal, India', *Asian-Pacific Newsletter on Occupational Health and Safety*, 15(3), 59-60.
12. Sue Hignett, Lynn Mc Atamney - Rapid Entire Body Assessment (REBA), *Applied Ergonomics* 31 (2000) 201- 2053.
13. Trevelyan, F.C. and Haslam, R.A. 2001. Musculoskeletal disorders in a handmade brick manufacturing plant. *International Journal of Industrial Ergonomics*. 27. pp. 43-55.

Appendix A : Brick making process

The mixture forms a dough like substance

The mud is now carried in a trolley to the moulding area .

A worker is assigned the job of moulding clay into bricks

On an average a worker moulds about 1500 bricks in a day. The batch is dried in open for 3 days in the same position.

Bricks ' position is changed to dry the beneath area for 2 days

Bricks are kept as these structures to aerate all surfaces equally. for 2 days

The bricks are carried to the kiln for heating process ina trolley (hand pulled). It carries 250 bricks at once.

A layer of coal pieces is spread after two layers of bricks.

This coal layer is heavily stuffed

Another layer of coal is spread on the 6th brick mat.

The batch of brciks is arranged as a heating hub

Brick pyramid is covered on the sides by faulty bricks or damaged bricks and sides are stuffed with coal.