Ergonomic intervention and redesigning of mould for traditional brick moulding workers

Kundu Amar, Ray G.G.
Indian Institute of Technology, Bombay, Mumbai, India, Email kundu.amar2010@gmail.com
Indian Institute of Technology Bombay, Mumbai, India, Email gaurgray@gmail.com

1 Introduction

The three basic requirements in our life is Food, Water & Shelter. In the earlier ages, people used to find shelter under caves. Due to modernization & urbanization people are now making more secure and comfortable accommodation like high rise building etc. Brick is the functional and structural unit of building. A brick is a block or a single unit of a kneaded clay-bearing soil, sand and lime or concrete material, fire hardened or air dried, used in masonry construction (Bricks Wikipedia). Bricks are one of the oldest types of building blocks. They are an ideal building material because they are relatively cheap to make, very durable and require little maintenance. Burnt bricks are the most popular building material in India. The Indian brick industry is the second largest producer of brick in the world, next to that of china. It is running as an unorganized small sector with more than 1, 00,000 brick-kiln units spread throughout the country, each unit manufacturing between 1 lakh to 10 million bricks per year. At present around 140 billion bricks are produced in those units (Singh AL and Asgher Md. S. 2005) (Saidapur, 2012). The Gangetic plains of North India comprising the states of Assam, Bihar, Haryana, Punjab, Uttar Pradesh (UP) and West Bengal account for about 65% of the total brick production of India, whereas peninsular and coastal India contribute the remaining 35%. The brick industry in India is highly labour-intensive employing about 15 million workers, and is characterized by the use of manual labour, and primitive and age old technology. As per the Economic Survey 2007-08 out of 440 million workers in India, 93% of the workers are in the unorganized sector. 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 any training. Therefore, they don't have any previous knowledge about unsafe acts and hazards related to this work, awkward postures, or they simply ignore the safe working process. In a brick making industry, there are five types of workers such as Patla (or Thopai) (who are responsible for mud making, ground cleaning, mud carrying from mud pool to moulding area, brick moulding and stacking green bricks after sun-dry), Bharai (who carries green bricks from moulding area to inside the kiln by head mode or with help of cycle or tractor), Khadkan (who arranges the bricks for uniform burning), Jalai (control the temperature of kiln, and proper firing) and Nikashi (Removes the fired red bricks from kiln to outside the kiln by using head mode or wheel barrow). High volume of workers (50 - 60%) in brick making industry works as Patla or Thopai (Moulder) and do the moulding activity through-out the whole season.

2 Aims and Objectives

The objective of the present study was to identify and evaluate the physiological and

biomechanical stresses accumulated by the molders due to load handling in awkward work postures, and to formulate probable remedial measures to reduce these stresses so that the musculoskeletal disorder (MSD) can be prevented and resulting in improvement of the health status of the workers.

3 Methodology

Selection of site and subjects: 20 Male and 7 female moulding workers were selected randomly from two brick kiln (Gujarat and Bihar) with age group 33.73 (± 11.39) years (Male) & 22.60 (± 3.97) years (Female) having minimum 3 years experience on that activity.

Assessment of physical characteristics of the subjects: The height of the subjects was measured by the Martin type anthropometric rod (Mfg by Seiber & Heigner, Switzerland) and weight was measured by a portable, calibrated bathroom weighing scale.

Biomechanical Study: Work posture analysis: Working postures were assessed by video capturing the operation by using Sony Handicam camera, followed by using the following tools:

OWAS method (Ovako Working Posture Analysis System) (Karhu et al., 1977), RULA method (Rapid Upper Limb Assessment) (McAtamney and Corlett, 1993), REBA method (Rapid Entire Body Assessment) (Hignett and McAtamney, 2000), Joint Angle study, A modified Nordic Questionnaire was also applied to know musculoskeletal problem of the workers. A user centered approach on moulders behavior and understanding the issues were made on board by personal interview method & observation method. Based on collected data, three different conceptual model of the mould were made by using Solidworks CAD modelling software. The CAD drawing was then converted to a full scale prototype for simulation study.

4 Description of Brick Moulding Activity

Out of five major activities in brick making industry, moulding is an essential part of brick making process, which includes six sub processes like, cutting the exact volume of mud from the heap of mud kept for brick moulding, (good mixture of clay), rolled in sand (for anti-sticking agent) and put into the mould, excess mud is removed and sand is spread above the mud, the entire mould is taken to the site and the mould is toppled upside down by the help of fingers of both hand so that the soft bricks comes out from the mould and the mould is again used for a new set of brick making (Figure 2).

5 Problem Identification

For making bricks one template/ (Locally name Sancha or Forma) is required. Sancha was made by wood (West Bengal, Bihar), or aluminum (Gujarat) (Figure 1). The weight of Sancha is 1- 1.5 kg. Brick moulding is a repetitive and continuous work performed in awkward squatting postures in which a load of around 6 -7 kg (mud plus mould) is handled each time by fingers and wrists of both hands with a frequency of 3 bricks per minute. This leads to a total load handling equivalent to 18 – 21 kg per minute. The workers (One Juti/couple) made 900-1000 bricks (male) and 600 – 700 bricks (female). Therefore, it can be estimated that male workers handled 7000 kg and female workers handled 4900 kg per day.

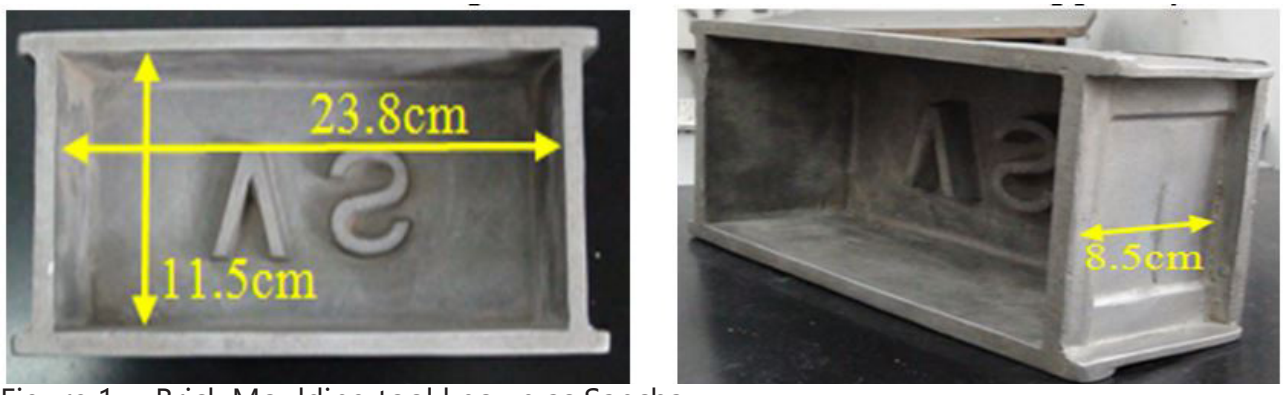

Figure 1. – Brick Moulding tool known as Sancha

In every brick making cycle, they use thumb for generating the force, and remaining fingers as pivot to topple the mould on the ground that the brick comes out of the mould easily on the ground. During moulding a high range of wrist movement at the rate of three movements per minute is seen among the workers. This unnatural degree of wrist bending (32.780±12.840) mostly consists of ulnar deviation, which in turn causes more adverse Musculo skeletal-disorder effect on worker's health especially to wrist joint movement. The main drawback of existing brick moulding method is that a large amount of load is handled by fingers and wrists of both hands demanding a high range of wrist bending in squatting posture. It is, therefore, essential to make our workers aware about the negative impact of the work condition and better way to perform the work. This will help them to continue their working life for a longer period under the conducive and safe work condition which in turn will influence not only on the working conditions, but also on the social security, health and safety of the workers. This long time awkward squatting posture may result in future serious injury in workers spinal cord. During the course of interaction with the workers frequent complaints were about lower back pain along with thigh, calf and ankle. The centre of gravity (CG) was shifted to backward from his/her normal posture due to squatting posture. Sometimes the workers also feel numbness due continuous stress in thigh muscle. The worker handled more than 6 kg load at every time with squatting posture. The workers complained of pain in lower back, thigh, hip, calf and ankle due to awkward postures. So the workers need to change their posture frequently. Ergonomically the most comfortable working posture is the one where our comfortable working posture in which our joints are naturally aligned. Working with the body in a neutral position reduces stress and strain on the muscle, tendons, and skeletal system and reduces risk of developing a musculoskeletal disorder (MSD). Continuous standing or sitting while working is a common source of discomfort and fatigue. Frequent changes of body positions, including alternating between sitting and standing, helps to avoid fatigue.

6 Results

The physical characteristics of the brick kiln workers are presented in Table 1. It shows the Mean (±SD) values of age and other physical parameters like height, weight, BMI of the subjects.

Table 1 Physical Characteristics of the Brick field Workers

Variables	Mean ± SD	
	Male (n=20)	Female (n=7)
Age (Yrs)	33.73±11.39	22.60±3.97
Body Weight (kg)	52.43 ± 8.8	43.40 ± 6.54
Height (cm)	161.04 ± 7.21	151.28 ± 6.07
BMI	20.21 ± 3.18	18.96 ± 2.53

Bio-mechanical assessment:

From the view point of biomechanics, two approaches were made; 1) work posture assessment and 2) assessment of localized hand, wrist, palm, and fingers fatigue during moulding.

1. Work Posture assessment

The entire process of manual brick moulding was divided into certain components for postural assessment. Different standardized methods were applied for each component to identify the risk factors associated with a particular task. Cutting mud, inserting mud into the mould and take out brick from the mould, were the main task components. Assessment by OWAS method revealed that all the postures were highly risky (Table 2) and corrective measures were required as soon as possible. In every stages of brick moulding RULA score was 7 suggesting action level 4 where intervention and changes are immediately required. REBA score was 10 or more than 10 in all the postures indicating corrective action including further assessment is immediately required. Based on posture evaluation scores (Table 2) it was clear that adoption of sustained squatting posture and moulding the bricks by forward bending, for hours after hours throughout the day, in the field is very detrimental for the workforce. It was evident that prolonged squatting posture caused numbness in the lower leg resulting from lack of blood supply due to sustained muscle compression. Changes in work posture and associated tools need immediate attention.

Table 2 Postural assessment of the brick moulders

Postures	OWAS Score Action Level	RULA Score Action Level	REBA Score Action Level
Cutting Mud	2, Corrective measures in near future	7, Investigate & change immediately	12, Very high risk Implement change
Inserting Mud In mould	2, Corrective measures in near future	7, Investigate & change immediately	10, High risk, Investigate implement change
Take out bricks from mould	4, Corrective measures immediately	7, Investigate & change immediately	12, High risk, Implement change

ISBN 978-93-5258-836-7

2. Assessment of hand, wrist, palm and finger movement

With reference to figure 4, it was reported that all moulders were suffering from pain in the fingers, wrists, hand and shoulder which are primarily related to moulding job because of the existing mould design mould design. To perform this job, workers had to adopt the squatting posture which put burden on upper back, lower back, both knees, both thighs and both ankles. Brick moulders were having more pain in the wrists and lower part of the body compared to the upper body part, because most of the time they sit continuously in the same awkward squatting posture for long hours to mould the bricks without taking proper rest interval. The task is repetitive in nature contributing to their major discomfort level.

7 Design Intervention

Based on anthropometric data, different conceptual models of the mould were developed by using solid works CAD software. The CAD drawing was then converted to a full scale prototype for stimulation study. Different new concepts were designed and fabricated with proper gripping for moulding activity. The new models will increase the productivity by delaying the physiological fatigue, resulting in reduction of preventing the expense of the human cost. Workers comfort was also taken into consideration while designing the mould.
Concept 1: One of the major problem areas of the above mould concepts. In the current mould concept the mud does not stick to the mould and thus making it easier for the raw brick to slip out of the mould. Removing of bricks from mould will be easier in this concept. There are two handles that will help to remove the bricks from mould in the current concept (Figure 2).
Concept 2: This concept is little modification of previous concept. Here we give two slots instead of handles (Figure 2). Removing of bricks from mould will be easier in this concept.
Concept 3: During brick moulding operation toppling is a strenuous job. So we are thinking to remove this operation for new design. The concept is given below (Figure 2). The brick making work station surface should be smooth to use this concept.

Figure 2. – Prototype of concept 1, Concept 2 & Concept 3 (Left to Right)

8 Conclusion

Biomechanical analysis indicates that the workers are continuously adapting awkward squatting postures, and lifting of load on their hands which results in whole segmental

pain and discomfort. It is needless to mention that the im-portance lies in a systematic intervention to relook at the better work posture and redesigning of the mould accordingly. In parallel steps, must be taken to create awareness for both the workers and management to protect this limited and valuable work force from depletion.

References

1. Hignett, S. and McAtamney, L., 2000. Rapid Entire Body Assessment (REBA). Appl. Ergon. 31 (2), 201-205.
2. http://en.wikipedia.org/wiki/Brick sited on 30th July, 2014
3. Karhu, O., Kansi, P., Kuornika, I., 1977. Correcting working postures in industry: a practical method for analyses. Appl. Ergon. 8(4), 199-201.
4. McAtamney, L., Corlett, E.N., 1993. RULA: a survey method for the investigation of work related upper limb disorders. Appl. Ergon. 24 (2), 91-99.

ISBN 978-93-5258-836-7