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Postural Assessment of Indian Masons and Prototype Design of Work Table

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Abstract: Indian Masons are engaged in different construction activities like bricklaying, plastering, and concreting work in prolonged standing, sitting, trunk flexion posture at lumbar, squatting, and truck twisting posture to pick the materials, tools and perform bricklaying and plastering work throughout the day. A different study revealed that prolonged working in flexion posture and working in squatting posture without supporting any fixture would cause work-related musculoskeletal disorders gradually. Earlier studies also showed that working in poor posture correlated with work-related musculoskeletal disorders. This study examines the influence of working in trunk flexion posture at the lumbar, trunk twisting, Neck twisting and squatting posture by the masons while performing different masonry work to find the discomfort among the Indian masons. The 64 male masons were observed and video-recorded at different construction sites. The REBA, ERIN, WERA and QEC methods are used for the assessment of exposure on the body. The assessment was performed on real-time images of masons performing bricklaying and plastering work. The REBA, ERIN, WERA and QEC results showed that masons were at high risk due to prolonged working in trunk flexion posture at the lumbar, working with twisting position of the trunk and Neck and squatting posture. The newly developed worktable will help the mason to reduce the risk of work-related musculoskeletal disorders.

Introduction

The construction workers are forced to do high physical, laborious and exhausting work at construction sites. The works to be carried out are excavation, material transportation and material preparation, formwork, rebar work, and masonry work, which includes bricklaying and plastering, electrical work, plumbing work, tilling, painting, furniture work, etc. These works are painstaking and need heavy physical strength. Construction work is the most hazardous work in which workers are adversely affected by work-related musculoskeletal disorders due to working in awkward postures (Antwi-Afari et al., 2018) and stress (Jabelli et al., 2018; Chakraborty et al., 2017). Chakraborty et al. (2017) revealed the relationship between stress, WRMSD and QoL among construction workers experiencing high-stress levels due to overwork and low quality of life. Assessment of WRMSD of the workers engaged in construction work is complicated due to continuous, dynamic and complex work tasks (Wang et al., 2015).

Masons are the backbone of the construction work. They are skilled and, most importantly, people who perform major construction work. In India, masons perform bricklaying, Plastering and concreting work. In addition, these people also perform some auxiliary work on the construction site. These works involve lifting bricks from the ground, for which they bend more than 90^0 at the lumbar, holding a pan filled with mortar and erection scaffolds, making props, etc. However, the main work of the mason is to lay bricks and plaster the wall

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and roof. The second job is to spread and smooth the concrete mix while concreting the roof and columns.

The bricklaying work includes tasks like 1) collection of mortar from iron pan (from the ground) (Task-BL-1), 2) laying /spreading of mortar on bed (Task-BL-2), 3) filling of bricks gap (Task-BL-3), 4) String lining (Task-BL-4), 5) Pick brick (from ground) (Task-BL-5), 6) Laying brick (Task-BL-6-(i)(ii)), 7) break brick (Task-BL-7).

Plastering is one of the main processes of construction work. It is performed to smoothen the wall surface. It covers rough walls, uneven house wall surfaces, and other construction work. Plastering materials are a mixture of fine sand, cement, and water. The plastering work includes tasks like (1) Applying mortar to the ceiling (Task-PL-1), (2) Levelling/planning the mortar applied on the ceiling (Task-PL-2), (3) Applying mortar on the inside wall (Task-PL-3), (4) Levelling/planning the mortar applied on inside wall (Task-PL-4), (5) Picking mortar for plastering the outside wall (from the ground) (Task-PL-5), (6) Apply mortar on the outside wall (Task-PL-6) and 7) Level/plain the mortar (Task-PL-7).

In plastering, the mason applies a base coat of mortar to the wall with the help of a trowel, spreads the mortar on the wall, and then flattens and smooths the mortar with the help of a metal float or aluminium channel. For roof plastering, masons use wooden floats to spread and smooth the plaster, and then metal floats are used for finishing instead of aluminium channels. For vertical wall plastering, the aluminium channel is used, which involves finishing interior and exterior walls to cover uneven or rough surfaces of walls.

Table 1 presents details of the work performed by the Indian mason, including the tools used, body postures, exposed body parts and related risks.

Table 1. Indian Masons' work details, tools used, body postures, exposed body parts and risk exposure.

Construction Occupations and Description of Work	Work carried by construction worker	Tools Used	General body Posture / Tasks	Exposure body parts*	Risk of Work-related musculoskeletal disorder**
Mason (Brick layer /plasterer) - Mason is a skilled worker engaged in bricklaying and plastering work.	# Pour and Spread mortar with the help of a brick trowel. #Lying brick to form a wall # Pouring concrete in column and slab # Check the level and the right angle at the corner with the help of Mason square. # Check the vertical alignment/equivalence of the wall with the help of Plumb Bob. # Plastering the wall with the help of a plasterer Trowel, wooden/metal Float and aluminium channel. # Applying mortar on the wall and spread and level it for plastering (inside/outside).	#Brick Trowel #Metal/wooden float. #Aluminium channel #Mason Square #Plumb bob #Water Level #Spirit level #Mason string (level line/line dori - a thread to align/upright wall). #Measuring tape #Concrete Vibrator	#Head/Neck - Flexion/ Extension, Lateral Left/Right, Rotation Left /Right #Shoulders- Flexion, Elevation/ Depression #Upper Arms- Flexion/ Extension, Abduction, Medial/Lateral Rotation. #Lower Arms- Flexion, Pronation/ Supination. #Hand/wrist- Flexion/Extension, Radial/ Ulnar Deviation. #Fingers/Thumbs, Flexion/Extension, Radial/Ulnar Deviation, Abduction/ Adduction	For Brickwork #Legs #Hand #Fingers #Lower back #Wrist #Elbow #Arms For Plastering #Legs #Hand #Wrist #Neck #Shoulder #Fingers #Eyes #Arms #Lower back	#Awkward Posture #Repetitive exertion #Forceful exertion #Frequency of Movement #Duration #Environmental Conditions #Visual Demands #Sychosocial factor #Individual factors

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	# Properly pouring Concrete on Slab. # Spreading and smooth finishing the concrete etc.		#Thoracic- Lateral Left/Right, Rotation Right/Left #Lumbar - Flexion /Extension, Lateral Left/Right, Rotation Right/Left #Thigh- Flexion, Abduction, Medial/ Lateral Rotation. #Leg- Flexion, Medial /Lateral Rotation. #Foot- Planter Flexion #Toes - Hyper-Extension. #Lifting/Lowering #Standing/stooping/ Squatting #Overhead #Apply force/load		
*Exposure body parts are Head/ Neck/ Shoulder/ Elbows/ Arms/ Hands/ Wrists/ Thumbs/ Eyes/ Back (Middle or Lower)/ Thighs/ Legs/ Knees/Ankles, Feet and Toes)					
**Risk of Work-related musculoskeletal disorder- 1) Awkward Posture, 2) Static /dynamic exertion, 3) Repetitive exertion, 4) Forceful exertion, 5) Frequency of Movement, 6) Duration, 7) Recovery, 8) Vibration, 9) Mechanical Compression, 10) Environmental Conditions, 11) Team Work 12) Visual Demands, 13) Psychosocial factors, 14) Individual factors					

A study reveals that the masons are working under high stress (Chakraborty et al., 2017), working in awkward postures (Boschman et al., 2013; Das et al., 2014; Rahman et al., 2012) and suffering from work-related musculoskeletal disorders (Dasgupta et al., 2014; Lee et al., 2013). Hence, this paper aims to (1) find the ergonomic risk level amongst the masons while performing bricklaying and plastering work and (2) create a virtual worktable design to reduce the risk level.

Methodology

An exploratory survey was carried out for 12 weeks at construction sites where bricklaying and plastering occurred. Seventy interviews and scribed recordings were made with masons, 64 of whom were involved in the described tasks. Table 2 shows that the masons who conducted the bricklaying and plastering work are predominantly of basic demographic profiles and criteria. The height and weight of the masons were taken using plain anthropometric scales and weighing machines. Data about age, years in practice, working hours a day, procedures implemented, pain or discomfort in certain body parts, other related concerns, and more of such data were recorded. The masons were between 28 and 52 years old, while the work experience ranged from 1 year to 36 years. The masons were involved in three types of work: bricklaying, plastering, and concreting. Table 3 shows that most bricklayers are between the ages of 31-40 and 41-50 and have 11 to 30 years of work experience. Table 2 shows that about 83% of the masons have completed primary education, 11 % have completed secondary education, 1.56% have completed intermediate education, and 4.69 % are illiterate. It has also been revealed that 56.25 % of masons are migrants.

Different procedures have been applied to analyze masons' working postures. These methods can measure various functions in any sitting position where the body's position is static, dynamic or changing quickly. These are quick survey methods for ergonomic interventions in workplaces where WRMSD is reported. This assessment method can apply biomechanical and postural loading on the laborers' bodies. Several methods have been developed to assess ergonomic risk. RULA (McAtamney et al., 1993), NIOSH (Waters et al., 1993), REBA (Hignett et al., 2000), QEC (David et al., 2008), WERA (Abd Rahman et al., 2011), ERIN (Rodriguez et al., 2013), NERPA (Sanchez-Lite et al., 2013) and NMQ (Lopez-Aragon et al., 2017) are some of them. This paper uses REBA, ERIN, WERA and QEC methods to evaluate the risk exposure.

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Table 2. Demographic characteristics of Masons' (n=64).

Characters	Mean ± SD
Age (years)	42.59±0.09
Weight (kg)	62.39±6.20
Height (cm)	163.75±4.47
Experience (years)	18.53±9.19
BMI (Kg/m^2)	23.23±1.69

Table 3. Number of Masons feeling pain.

Parameter	Category	No. of workers feel pain	Percentage of workers feel pain
Age	21-30	8	12.50
	31-40	19	29.69
	41-50	23	35.94
	≥ 51	14	21.88
Experience	00 - 10	16	25.00
	11-20	24	37.50
	20 - 30	15	23.44
	≥ 30	9	14.06
Education	Illiterate	3	4.69
	Primary	53	82.81
	Secondary	7	10.94
	Intermediate	1	1.56
Migrant		36	56.25

Results

The research was conducted on masons who performed brick-laying and plastering works. Each posture was assessed for risk factors using the REBA, ERIN, WERA, and QEC models for all the tasks incorporated in the bricklaying and plastering operations. Thus, eight postures for bricklaying and 11 postures for Plastering were chosen for the evaluation. Figures 5(a) to 5(g) and 6(a) to 6(g) depict actual pictures of the bricklaying and plastering postures investigated in this paper. The survey was carried out at more than one construction site. The respondents filled out the questionnaire incorporating pain or discomfort felt in certain body parts, the frequency of such feelings at each time interval, and the psychosocial factors.

Table 4 and Figure 1 reveal that the masons complained about pain in the lower back (84.38%), shoulders (79.69%), wrist (43.75%), elbow, finger and thumb (29. 69%). Table 5 and Figure 3 shows that more masons have pain after working time (57.81%) and in the morning (23.44%).

Table 6 and Figure 4 show that 87.50% of masons work in awkward postures, 76.56% of masons are addicted to some bad habits, 57.81% of masons have pain due to physically exhausting, 34.38% due to the pace of work and 25% due to pervasive jobs.

Table 4. Feeling pain in different body parts by the masons (n=64).

Body Parts	Total	Percentage
Head	4	6.25
Neck	13	20.31
Shoulders	51	79.69
Chest	2	3.13
Elbow	19	29.69
Arms/Hands	14	21.88
Wrists	28	43.75
Fingers/Thumbs	19	29.69
Upper back	12	18.75
Lower back	54	84.38
Thigh/ hip/ buttocks	0	0.00
Legs	8	12.50
Knees	0	0.00
Ankle/ feet/toe	2	3.13

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Figure 2 shows that 25% of masons have pain in the lower back, 23% in the shoulder, 12% in their wrists, and 8% in their fingers/thumbs and elbows.

The risk scores for selected postures in bricklaying and Plastering using REBA, ERIN, WERA and QEC methods are shown in Tables 7-10 and 11-14, respectively.

Table 5. Pain at different time zones by all workers.

Time zones	Total	Percentage
During working	6	9.36
After working	37	57.81
During Sleeping	5	7.81
In the morning	15	23.44

Table 6. Distribution of pain incidence due to various occupational and social parameters.

Parameters	Total	Percentage
Working in an Awkward Posture	56	87.50
Pace of work	22	34.38
Pervasive jobs	16	25.00
Traumatic Incidents	2	3.13
Addiction to Alcohol/ chewing tobacco smoke	49	76.56
Social support	12	18.75
Physically Exhausted	37	57.81

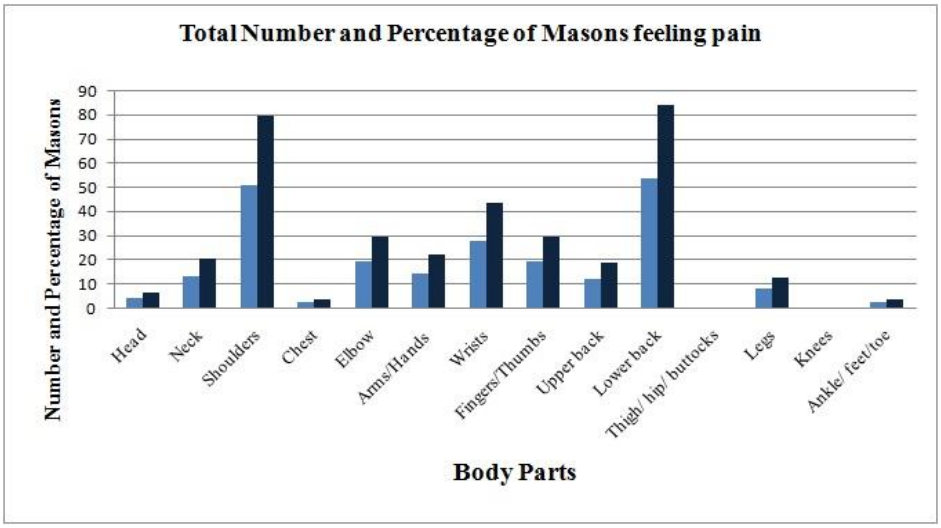

Figure 1. Pain feelings in different parts.

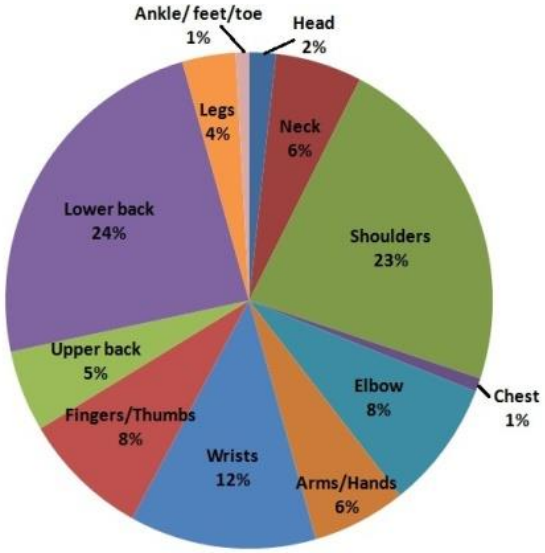

Figure 2. Percentage of body parts feeling.

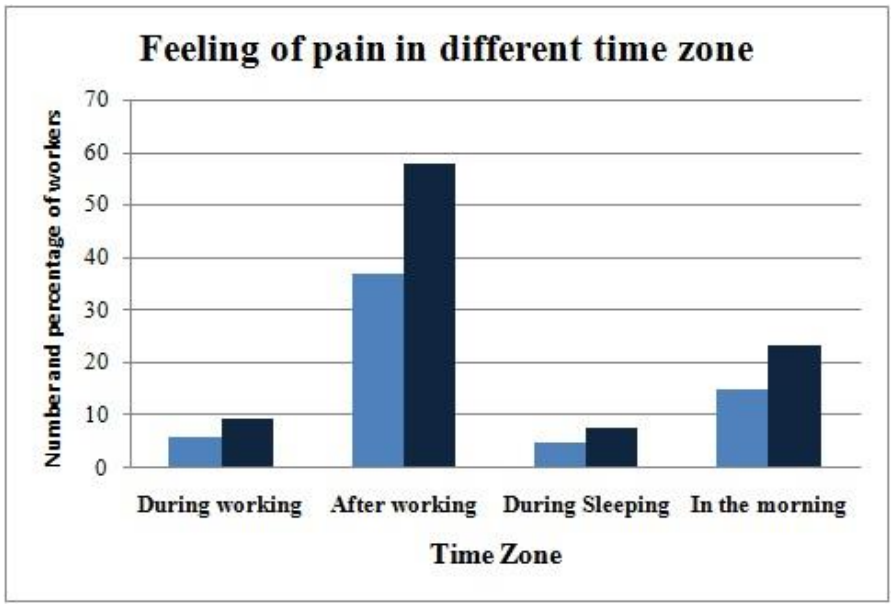

Figure 3. Pain at different time zones by all workers.

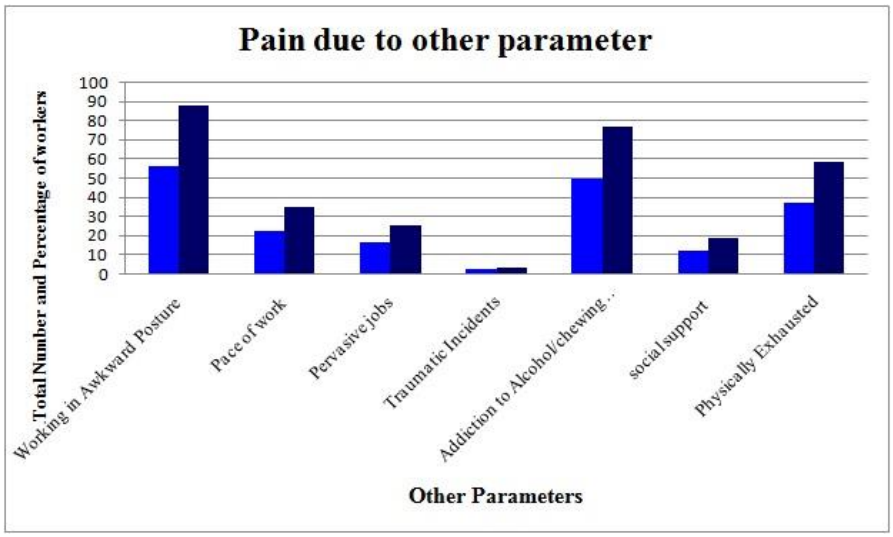

Figure 4. Details of pain due to other parameters.

Results of Bricklaying working posture having high risk using REBA, ERIN, WERA and QEC.

(a) Collect mortar from iron pan (BL-1)

(b) laying of mortar bed (BL-2)

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c) Filling bricks gap (BL-3)

d) Adjust level (BL-4) String Line (Adjust Level and line)

(e) Picking of Brick (from the ground) (BL-5)

(i) (ii)

(f) Laying of Brick (BL-6)

(g) Breaking of Brick (BL-7)

Figure 5. Real-time images of Masons performing bricklaying work.

Brickwork involves 1) collection of mortar (T-1), 2) pouring and spreading of mortar on the bed (T-2), 3) filling the gaps of the bricks (T-3), 4) level line with strings (T-4),5) Pick/lifting bricks (T-5), 6) laying bricks to build walls (T-6),7) break brick (T-7). The mason breaks the bricks to the required size with the help of a trowel when needed.

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Table 7. Ergonomics Risk Scores of REBA (Bricklaying Work).

		1	2	3	4	5	6		7
STEPS	**BP**	**BL-1**	**BL-2**	**BL-3**	**BL-4**	**BL-5**	**BL-6(i)**	**BL-6(ii)**	**BL-7**
A: NECK, TRUNK AND LEG									
1	**N**	2	2	3	3	2	3	3	3
2	**BK/T**	4	3	3	4	5	3	4	4
3	**L**	3	3	4	4	3	4	3	4
4	**PS-A**	7	6	8	9	8	8	8	9
5	**LD/T**	0	0	0	0	0	0	0	0
6	**TS-A**	**7**	**6**	**8**	**9**	**8**	**8**	**8**	**9**
B: ARMS AND WRIST									
		L R	L R	L R	L R	L R	L R	L R	L R
7	**UA**	2 3	3 2	3 3	3 3	1 3	1 2	4 4	2 2
8	**LA**	1 2	1 1	1 1	1 1	2 2	2 2	1 1	1 1
9	**W**	1 2	2 3	2 2	2 2	1 2	2 2	2 2	2 2
10	**PS-**	1 5	4 3	4 4	4 4	1 5	2 3	5 5	2 2
11	**CS**	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
12	**TS-**	**1 5**	**4 3**	**4 4**	**4 4**	**1 5**	**2 3**	**5 5**	**2 2**
	TS-	7 9	7 6	9 9	10 10	8 10	8 8	10 10	9 9
13	**AS**	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1
	FS	**8* 10***	**8* 7#**	**10* 10***	**11& 11&**	**9* 11&**	**9* 9***	**11& 11&**	**10* 10***
@ - Low risk, # - Medium risk, * - High risk, & - Very High risk									

Table 8. Ergonomics Risk Scores of ERIN (Bricklaying Work).

	1		2		3		4		5		6				7	
BP	**BL-1**		**BL-2**		**BL-3**		**BL-4**		**BL-5**		**BL-6(i)**		**BL-6(ii)**		**BL-7**	
	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
B	7	7	4	4	4	4	4	4	8	8	6	6	6	6	4	4
S/	2	5	2	5	2	2	5	5	2	5	2	2	5	5	2	2
H/	5	5	2	5	4	4	2	5	2	5	2	4	4	4	4	4
N	2	2	6	6	6	6	7	7	6	6	6	6	6	6	7	7
R	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
IO	6	6	6	6	6	6	6	6	8	8	6	6	6	6	6	6
SA	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
GR	**27***	**30***	**25***	**31***	**27***	**27***	**29***	**32***	**31***	**37&**	**27***	**29***	**32***	**32***	**28***	**28***
@ - Low risk, # - Medium risk, * - High risk, & - Very High risk																

Table 9. Ergonomics Risk Scores of WERA (Bricklaying Work).

	1		2		3		4		5		6				7	
BP	**BL-1**		**BL-2**		**BL-3**		**BL-4**		**BL-5**		**BL-6(i)**		**BL-6(ii)**		**BL-7**	
PART																
	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
S	4	4	4	4	4	3	4	4	3	4	4	4	4	4	2	4
W	4	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5
BK/T	5	5	5	5	4	4	4	4	5	5	5	4	5	5	4	4
N	6	5	4	5	3	4	5	5	6	5	4	4	5	5	3	5
L	5	5	5	5	5	6	6	6	5	5	5	6	4	5	5	6
PART																
LD/F	4	5	4	4	3	3	3	3	4	4	3	3	4	4	3	3
V	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
CST	5	6	6	6	4	6	6	6	6	6	6	6	2	6	6	6
TD	4	5	4	4	2	4	4	4	4	4	3	4	3	4	3	4
FS	**40**	**45 &**	**41**	**42**	**34 ***	**39 ***	**41 ***	**41**	**42 ***	**42 ***	**39**	**40**	**36 ***	**42 ***	**35 ***	**41 ***
@ - Low risk, # - Medium risk, * - High risk, & - Very High risk																

Table 10. Ergonomics Risk Scores of QEC (Bricklaying Work).

	1	2	3	4	5	5		7
Body Parts / Score	**BL-1**	**BL-2**	**BL-3**	**BL-4**	**BL-5**	**BL-6(i)**	**BL-6(ii)**	**BL-7**
Observer's Assessment								
BK/T								
A	A3	A2	A2	A2	A3	A2	A3	A2
B	B1	B1	B1	B1	B1	B1	B1	B1
S/LA/UL								
C	C2	C2	C2	C2	C2	C2	C2	C2
D	D2	D2	D2	D2	D2	D2	D2	D2
W/H								
E	E2	E2	E2	E2	E2	E2	E2	E2
F	F2	F2	F2	F2	F2	F2	F2	F2
N								
G	G3	G3	G2	G3	G2	G3	G2	G2
Workers Assessment								
H	H1	H1	H1	H1	H1	H1	H1	H1
J	J3	J3	J3	J3	J3	J3	J3	J3
K	K2	K2	K2	K2	K2	K2	K2	K2
L	L2	L2	L2	L2	L2	L2	L2	L2
M	M1	M1	M1	M1	M1	M1	M1	M1
N	N1	N1	N1	N1	N1	N1	N1	N1
P	P2	P2	P2	P2	P2	P2	P2	P2
Q	Q2	Q2	Q2	Q2	Q2	Q2	Q2	Q2

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Exposure to back (Static)	28*	24*	24*	24*	28*	24*	28*	24*
Exposure to back (Moving)								
Exposure to shoulder/arm	30#	30#	30#	30#	30#	30#	30#	30#
Exposure to wrist/hand	36*	36*	36*	36*	36*	36*	36*	36*
Exposure to Neck	18&	18&	16&	18&	16&	18&	16&	16&
Exposure while driving	1@	1@	1@	1@	1@	1@	1@	1@
Exposure when working with	1@	1@	1@	1@	1@	1@	1@	1@
Exposure due to work pace	4#	4#	4#	4#	4#	4#	4#	4#
Total stress exposure	4#	4#	4#	4#	4#	4#	4#	4#
@ - Low risk, # - Medium risk, * - High risk, & - Very High risk								

Results of plastering posture having high risk using REBA, ERIN, WERA and QEC.

(i) (ii)

(a) Applying mortar to ceiling (PL-1)

(i) (ii)

(b) Level /Plan the mortar (PL-2)

(i) (ii)

(c) Applying mortar on the wall (for inside plastering) (PL-3)

(i) (ii)

(d) Level/plain the mortar (for inside plastering) (PL-4)

(e) Picking mortar for Plastering (to apply on the wall) (for outside Plastering) (PL-5)

(f) applying mortar on the wall (for outside Plastering) (PL-6)

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(g) level / plain the mortar (for outside Plastering) (PL-7)

Figure 6. Real-time images of Masons' performing plastering work.

Table 11. Ergonomics Risk Scores of REBA (Plastering Work).

		1	2	3		4		5	6	7	
STEPS	**BP**	**PL-1(i)(ii)**	**PL-2(i)(ii)**	**PL-3(i)**	**PL-3(ii)**	**PL-4(i)**	**PL-4(ii)**	**PL-7**	**PL-8**	**PL-9**	
A: NECK, TRUNK AND LEG											
1	**N**	3	3	2	2	2	2	2	3		3
2	**B**	3	3	2	2	2	2	5	5		3
3	**L**	2	2	2	4	2	4	3	3		4
4	**P**	6	6	4	6	4	6	8	9		8
5	**L**	0	0	0	0	0	0	0	0		0
6	**T**	**6**	**6**	**4**	**6**	**4**	**6**	**8**	**9**		**8**
B: ARMS AND WRIST											
		L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
7	**U**	1	4	1	5	1	4	1	5	4	1	4	3	1	4	2	4	5	5
8	**L**	1	2	2	2	1	2	1	2	2	2	2	2	1	2	1	2	2	2
9	**W**	2	3	1	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2
10	**P**	2	7	1	8	2	6	2	8	6	2	6	5	2	6	2	6	8	8
11	**C**	2	0	0	0	2	1	1	1	2	2	1	1	0	1	0	1	1	1
12	**T**	**4**	**7**	**1**	**8**	**4**	**7**	**3**	**9**	**8**	**4**	**7**	**6**	**2**	**7**	**2**	**7**	**9**	**9**
	T	7	9	6	9	4	7	6	10	8	4	9	8	8	10	9	11	10	10
13	**A**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	FS	**8 ***	**10 ***	**7 #**	**10 ***	**5 #**	**8 ***	**7 #**	**11 &**	**9 ***	**5 #**	**10 ***	**9 ***	**9 ***	**11 &**	**10 ***	**12 &**	**11 &**	**11 &**
@ - Low risk, # - Medium risk, * - High risk, & - Very High risk											

Table 12. Ergonomics Risk Scores of ERIN (Plastering Work).

	1		2		3				4				5		6		7	
B P	**PL-1(i)(ii)**		**PL-2(i)(ii)**		**PL-3(i)**		**PL-3(ii)**		**PL-4(i)**		**PL-4(ii)**		**PL-5**		**PL-6**		**PL-7**	
	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
BK/T	4	4	6	6	6	6	2	2	6	6	2	2	8	8	8	8	6	6
S/LA	2	6	5	9	2	9	2	9	6	2	6	6	2	5	2	9	9	9
H/W	2	5	2	5	4	5	4	6	5	4	5	5	5	6	4	6	4	4

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N	7	7	7	7	7	7	6	6	7	7	7	7	7	7	7	7	7	7
R	3	3	3	3	3	6	3	6	3	3	3	3	3	6	3	6	3	3
IOE	8	8	8	8	8	8	6	6	8	8	6	6	6	8	6	8	8	8
SA	3	3	3	3	3	3	2	2	3	3	2	2	3	3	3	3	3	3
GR	**29 ***	**36 &**	**34 ***	**41 &**	**33 ***	**44 &**	**25 ***	**37 &**	**38 &**	**33 ***	**31 ***	**31 ***	**34 ***	**43 &**	**33 ***	**47 &**	**40 &**	**40 &**
@ - Low risk, # - Medium risk, * - High risk, & - Very High risk																		

Table 13. Ergonomics Risk Scores of WERA (Plastering Work).

	1		**2**		**3**				**4**				**5**		**6**		**7**	
BP	**PL-1(i)(ii)**		**PL-2(i)(ii)**		**PL-3(i)**		**PL-3(ii)**		**PL-4(i)**		**PL-4(ii)**		**PL-7**		**PL-8**		**PL-9**	
PART A																		
	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
S	2	5	2	5	2	5	2	5	5	4	5	4	3	5	4	5	5	5
W	3	5	2	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
BK/T	4	4	4	4	3	3	4	4	2	2	4	4	5	5	5	5	4	4
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
L	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6
PART B																		
LD/F	4	3	3	3	2	3	3	3	2	2	3	3	4	4	4	4	3	3
V	3	4	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
CST	6	6	4	6	4	4	6	6	6	6	6	6	6	6	6	6	6	6
TD	5	6	4	4	5	4	3	3	4	4	3	3	4	4	4	4	4	4
FS	**38 ***	**44 ***	**32 ***	**42 ***	**36 ***	**39 ***	**38 ***	**41 ***	**39 ***	**38 ***	**41 ***	**40 ***	**42 ***	**44 ***	**43 ***	**44 ***	**43 ***	**43 ***
@ - Low risk, # - Medium risk, * - High risk, & - Very High risk																		

Table 14. Ergonomics Risk Scores of QEC (Plastering Work).

	1	**2**	**3**		**4**		**5**	**6**	**7**
Body Parts / Score	**PL-1(i)(ii)**	**PL-2(i)(ii)**	**PL-3(i)**	**PL-3(ii)**	**PL-4(i)**	**PL-4(ii)**	**PL-7**	**PL-8**	**PL-9**
BK/T									
A	A2	A2	A2	A1	A2	A2	A3	A3	A2
B	B1	B1	B1	B1	B1	B1	B1	B1	B1
S/LA/UL									
C	C3	C3	C3	C3	C3	C3	C3	C3	C3
D	D2	D2	D2	D2	D2	D2	D2	D2	D2

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W/H									
E	E2	E2	E2	E2	E2	E2	E2	E2	E2
F	F2	F2	F2	F2	F2	F2	F2	F2	F2
N									
G	G3	G3	G3	G3	G3	G3	G3	G3	G3
H	H2	H1	H2	H1	H1	H1	H1	H1	H1
J	J2	J2	J2	J2	J2	J2	J2	J2	J2
K	K2	K2	K2	K2	K2	K2	K2	K2	K2
L	L2	L2	L2	L2	L2	L2	L2	L2	L2
M	M1	M1	M1	M1	M1	M1	M1	M1	M1
N	N1	N1	N1	N1	N1	N1	N1	N1	N1
P	P2	P2	P2	P2	P2	P2	P2	P2	P2
Q	Q3	Q3	Q3	Q3	Q3	Q3	Q3	Q3	Q3
Exposure to back (Static)	18#	18#	18#	14@	18#	18#	22#	22#	18#
Exposure to back (Moving)									
Exposure to shoulder/arm	28#	28#	28#	28#	28#	28#	28#	24#	32*
Exposure to wrist/hand	30#	30#	30#	30#	30#	30#	30#	30#	30#
Exposure to Neck	14*	14*	14*	14*	14*	14*	14*	14*	14*
Exposure while driving	1@	1@	1@	1@	1@	1@	1@	1@	1@
Exposure when working with vibration	1@	1@	1@	1@	1@	1@	1@	1@	1@
Exposure due to work pace	4#	4#	4#	4#	4#	4#	4#	4#	4#
Total stress exposure	4#	4#	4#	4#	4#	4#	4#	4#	4#
@ - Low risk, # - Medium risk, * - High risk, & - Very High risk									

Various masonry works on bricklaying (BL) and plastering (PL) have been evaluated. The bricklaying work includes tasks like 1) collection of mortar from iron pan (from the ground) (Task-BL-1), 2) laying /spreading of mortar on bed (Task-BL-2), 3) filling of bricks gap (Task-BL-3), 4) String lining (Task-BL-4), 5) Pick brick (from ground) (Task-BL-5), 6) Laying brick (Task-BL-6-(i)(ii)), 7) break brick (Task-BL-7). The plastering work includes tasks like 1) applying mortar to the ceiling (Task-PL-1), 2) levelling/plaining the mortar applied on the ceiling (Task-PL-2), 3) applying mortar on the inside wall (Task-PL-3), 4) levelling/plaining the mortar applied on inside wall (Task-PL-5) Picking mortar for plastering the outside wall (from ground) (Task-PL-5), 6) apply mortar on outside wall (Task-PL-6) and 7) level/plain the mortar (Task-PL-7). During all these tasks, masons worked in different postures as per the work requirement. Each task has a different posture. In this study, highly awkward postures were considered. The results of the REBA, ERIN, WERA and QEC are presented.

Bricklaying

The findings of REBA and WRST methodologies in evaluating the strenuous activities involved in bricklaying

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tasks were further affirmed by ERIN, WERA and QEC methods, suggesting that all the computed factors for tasks and postures were considered to be at high to very high ergonomic risk. The REBA scores analysis indicated that Task BL-3 in both postures is at very high risk, whereas in Task BL-4, both sides are at high risk. The same was observed with the findings of the ERIN method. Furthermore, the method proposed by REBA also noted postures BL-5, as shown in Figure 5(e) and BL-6, as shown in Figure 5(f(ii)), as posing a very high risk. The WERA method also suggested that every task is dangerous for the shoulders and upper limbs, and Task BL-1 is highly dangerous for the right side. The incidence of overall stress exposure for all tasks and postures was found to be Medium. While evaluating the respective risk for the body parts, it was revealed that the risk factor was very high for the neck, wrist/hand, and the shoulder/arm, which was found to be at medium risk per the QEC method. If masons employed in a particular project are confined to those fixed positions for long hours, they stand a significant threat.

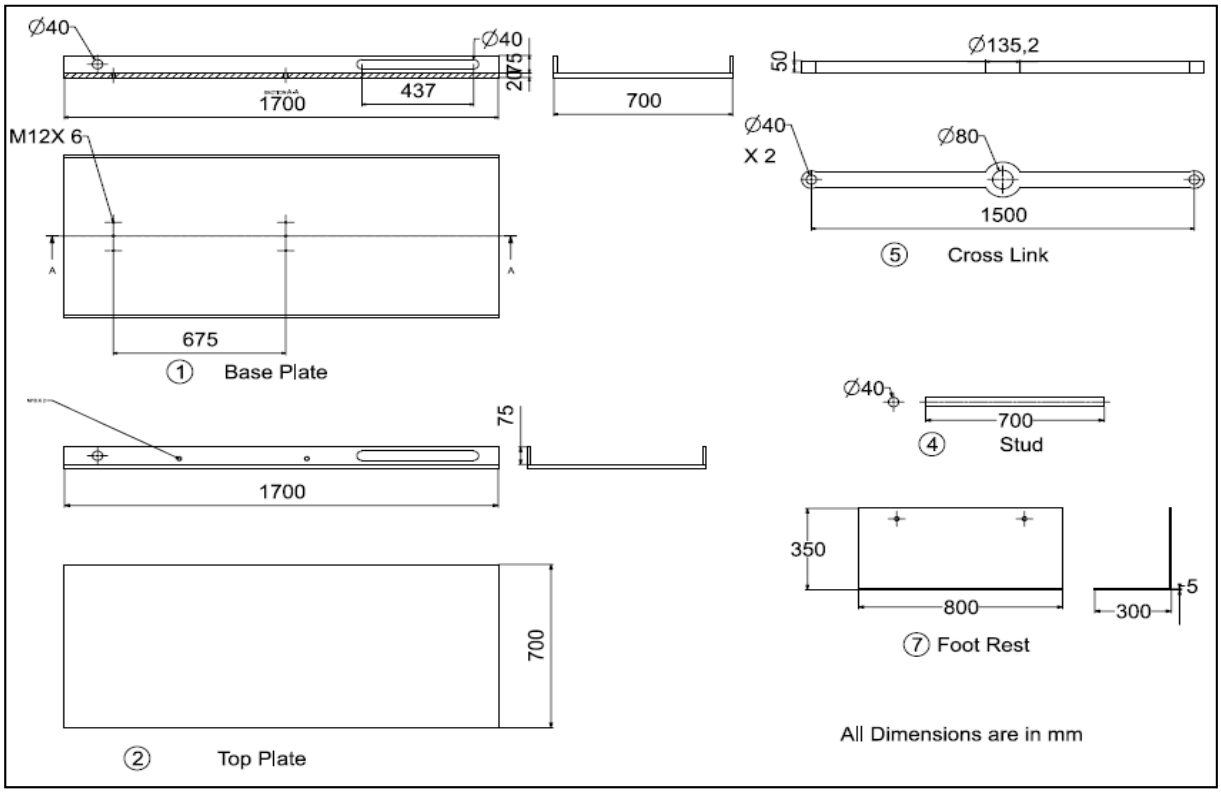

Figure 7. Detailed Drawing of Proposed Working Table (Parts).

Plastering

Moreover, REBA, ERIN, WERA and QEC for plastering tasks assessment revealed that all the tasks and postures are at high risk. REBA and ERIN methods scores revealed that all the postures employed for performing all seven tasks are at high risk. REBA method results revealed that the right side of the workers is at very high risk for tasks PL-3, PL-5, PL-6 and PL-7, while ERIN method results revealed that all tasks, particularly the right side, are very high risk except PL-4. The result obtained from the WERA methods again shows that all the tasks performed in plastering work are at high risk and require immediate correction. The QEC method results revealed that all the tasks are at medium risk for exposure, but exposure to the Neck is high.

Design of Working Table for Mason

The new working table for Mason was designed, modeled and assembled using Siemens NX 12.1 Module. Figures 7, 8 and 9 show the detailed drawing of the working table. The size of each part of the workbench has been taken from real-time requirements. The table's top and base plate size is 1700 mm × 700 mm. The hydraulic cylinder is provided for the table's up-and-down movement. The footrest is provided at the centre of the table and is 800mm x 300mm x 350mm. A support plate of size 300mm x 310mm has been provided on both sides of the top plate to keep materials and tools used in construction work. While designing the working bench, the body balance technology was used to ensure proper balance when Mason stood on the footrest and top plate. The table's minimum and maximum vertical height is 400 mm and can be extended vertically up to 1200 mm. This minimum and maximum height were determined by taking the average length of the inner side of the leg, as shown in Figure 10.

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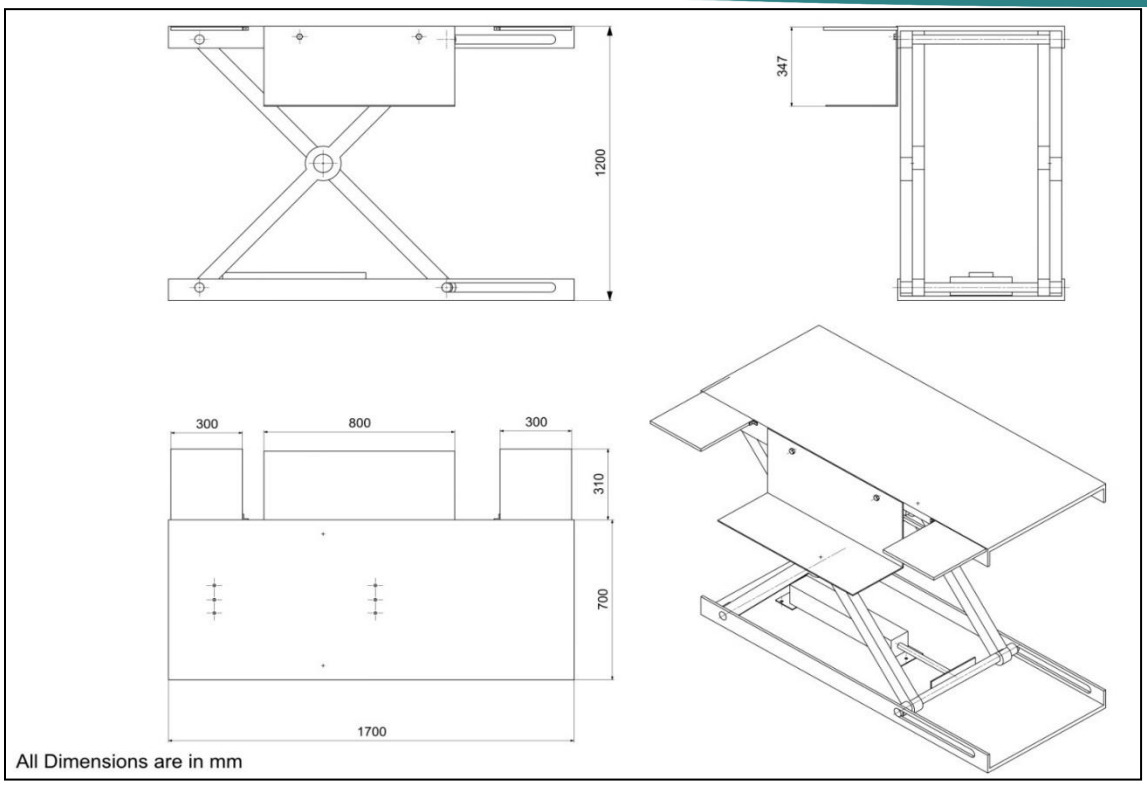
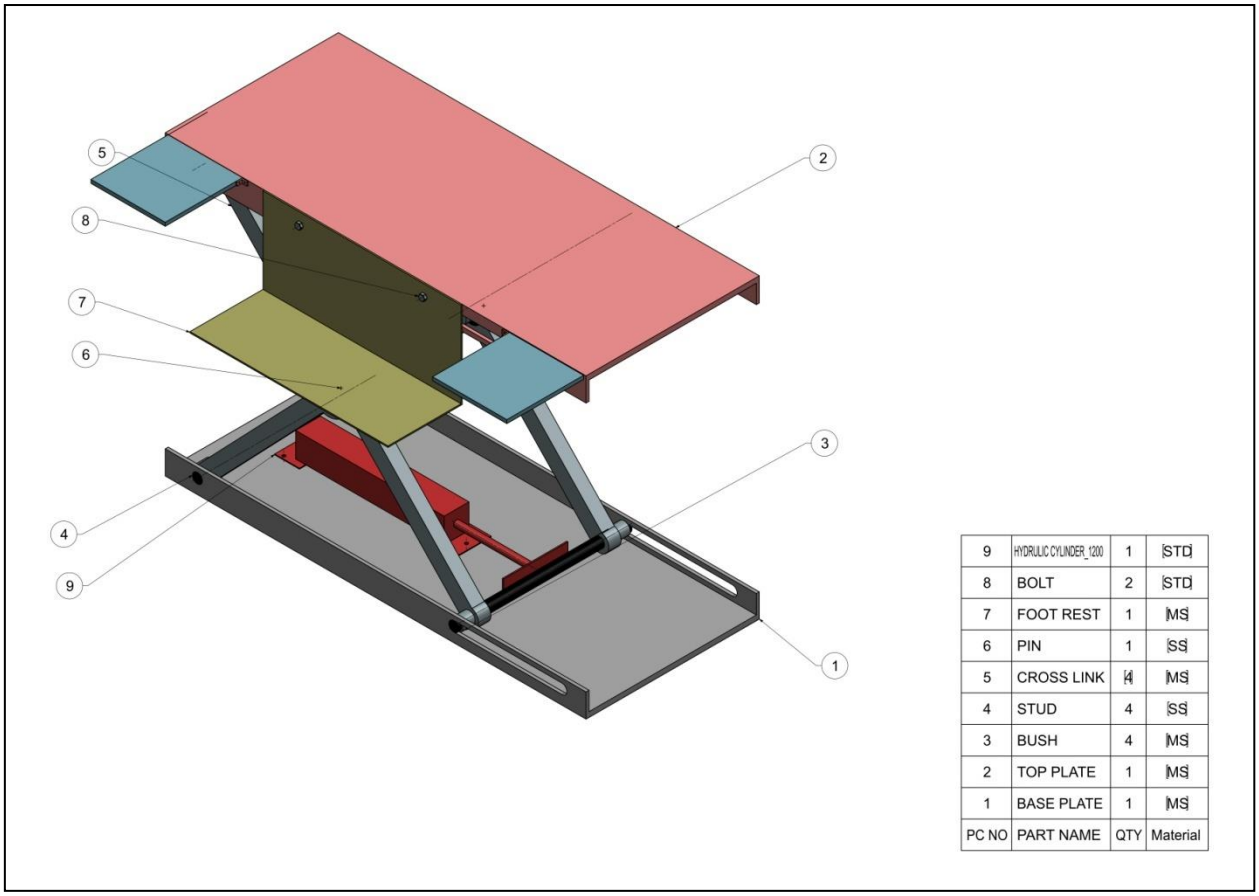


Figure 8. Drawing of working Table (with Top view, Front view, Side view and Isometric view).



PC NO	PART NAME	QTY	Material
9	HYDRULIC CYLINDER_1200	1	STD
8	BOLT	2	STD
7	FOOT REST	1	MS
6	PIN	1	SS
5	CROSS LINK	4	MS
4	STUD	4	SS
3	BUSH	4	MS
2	TOP PLATE	1	MS
1	BASE PLATE	1	MS

Figure 9. Drawing of Working Table with BOI and Maximum height (1200 mm).

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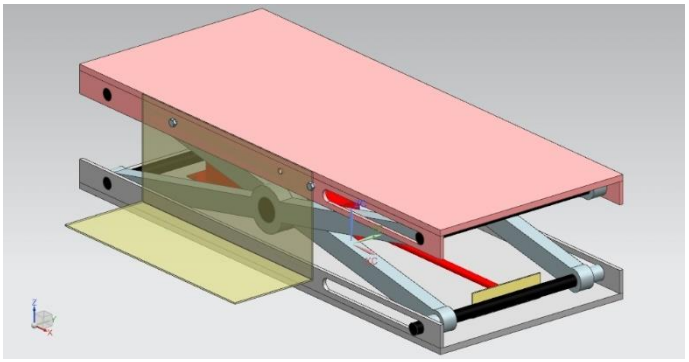

Figure 10. Working Table with minimum height (400 mm).

Figure 11. Manikin works in a sitting position while resting its foot-on-foot rest.

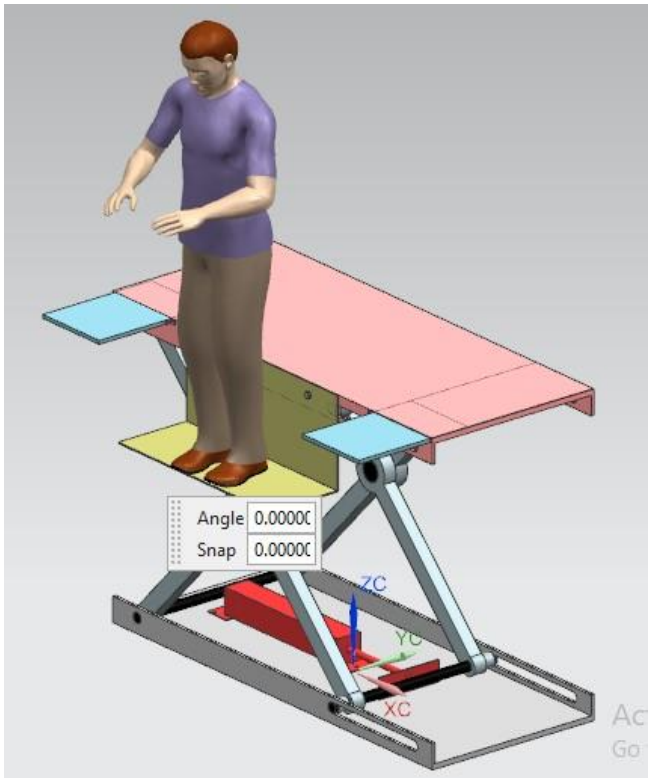

Figure 12. Manikin working on standing position while resting its foot-on-foot rest.

Discussion

The research results of this study show significant evidence of the relationship between awkward working posture and work-related musculoskeletal disorders in masons. These disorders are associated with prolonged posture activities like standing, sitting, forward bending, squatting, and twisting the trunk during work. Also, masons have a high risk of WRMSD since they work in abducted posture at the lower body, repetitive work, trunk flexion, wrist flexion and extension, and lumbar flexion for more than average angle and prolonged periods to complete their work (Das et al., 2017; Singh and Sharma, 2023; Tripathi et al., 2023; Kumawat et al., 2024). All real-time figures show that masons work at a very high ergonomic risk level in bricklaying and plastering work.

For hazardous posture levels, the masons have been perceived to work in a bending position at the lumbar (trunk flexion). Wrist and fingers are engaged for long periods to pick and hold the tools and materials like brick and pan with mortar, and they do not work according to the recommended standards. Working in such postures leads to development of low back pain (Garcia et al., 2018; Tissot et al., 2009; O'Sullivan et al., 2002)

A study by Behesthti et al. (2014) shows that plasterers suffer from the upper body and upper arm pain and failed to assess Neck, elbow, wrist, repetition and duration of work.

Prolonged standing increases physiological and ergonomic risk of work-related musculoskeletal disorders (Garcia et al., 2018). Lack of knowledge, proper training

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and guidance, properly designed ergonomic tools and equipment, and poor habits also contribute to WRMSD (Gajbhiye et al., 2022). Factors like working in awkward posture, year, pervasive jobs, traumatic incidences and age are also responsible for the development of WRMSD (Gajbhiye et al., 2023).

Bricklaying work, Table 15 shows the comparison of results obtained from different methods used to evaluate the ergonomics risk for bricklaying work. The results of REBA, ERIN, and WERA show that all the postures studied are at high ergonomic risk, while tasks BL-4 and BL-6(ii) are at very high ergonomic risk. The QEC

Figure 13. Manikin is working on a standing position on top.

Table 15. Comparative result of REBA, ERIN, WERA and QEC for Bricklaying work

TASK	SIDE	REBA	ERIN	WERA	QEC
BL-1	LEFT	HR	HR	HR	MR
	RIGHT	HR	HR	VHR	MR
BL-2	LEFT	HR	HR	HR	MR
	RIGHT	MR	HR	HR	MR
BL-3	LEFT	HR	HR	HR	MR
	RIGHT	HR	HR	HR	MR
BL-4	LEFT	VHR	HR	HR	MR
	RIGHT	VHR	HR	HR	MR
BL-5	LEFT	HR	HR	HR	MR
	RIGHT	VHR	VHR	HR	MR
BL-6 (i)	LEFT	HR	HR	HR	MR
	RIGHT	HR	HR	HR	MR
BL-6 (ii)	LEFT	VHR	HR	HR	MR
	RIGHT	VHR	HR	HR	MR
BL-7	LEFT	HR	HR	HR	MR
	RIGHT	HR	HR	HR	MR

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method results show that all the tasks are at medium risk. The result of QEC also shows a medium risk to the mason due to work pace. If masons work in a static posture, they will be at high risk to the back and high exposure to the Neck if they work in twisting, bending and prolonged periods in static posture.

Table 16. Comparative result of REBA, ERIN, WERA and QEC for Plastering. work

TASK	Side	REBA	ERIN	WERA	QEC
PL-1(i)(ii)	Left	HR	HR	HR	MR
	Right	HR	VHR	HR	MR
PL-2 (i)(ii)	Left	MR	HR	HR	MR
	Right	HR	VHR	HR	MR
PL-3 (i)	Left	MR	HR	HR	MR
	Right	HR	VHR	HR	MR
PL-3 (ii)	Left	MR	HR	HR	MR
	Right	VHR	VHR	HR	MR
PL-4 (i)	Left	HR	VHR	HR	MR
	Right	MR	HR	HR	MR
PL-4 (ii)	Left	HR	HR	HR	MR
	Right	HR	HR	HR	MR
PL-5	Left	HR	HR	HR	MR
	Right	VHR	VHR	HR	MR
PL-6	Left	HR	HR	HR	MR
	Right	VHR	VHR	HR	MR
PL-7	Left	VHR	VHR	HR	MR
	Right	VHR	VHR	HR	MR

The plastering work Table 16 compares results obtained from different methods used to evaluate the plastering work postures of the Masons. The results of the REBA method show that the masons' right side for tasks PL-3 (ii), PL-5, and PL-6 are at very high risk, while both sides of task PL-7 are at very high risk. The ERIN method shows that the right side of the masons for the task of all tasks except PL-4(i) (ii) is at high risk, while both sides of the masons while performing task PL-7 are at a very high ergonomics risk level. The WERA method shows that all the plastering tasks the show masons perform are at high risk. QEC method shows that similar to the WERA method, all plastering tasks are at medium risk; however, exposure to the Neck is high because masons have to twist and bend their Neck while plastering the ceiling, inner wall, inner staircase, and sometimes plastering the wall also. Like bricklaying work, the QEC shows a medium risk to the mason due to work pace while plastering work. If Mason works in a static posture, they will be at medium risk to their back while having very high exposure to the Neck if they twists and bends the Neck and works for a prolonged period in the static position of the Neck, as shown in Figure 6.

The study revealed that masonry workers are at high ergonomic risk because of inappropriate workplace posture, which should be avoided (Kibria., 2023). The weight, Poor lifting posture, lifting materials, and tools on one side of the body strain the trunk (Kibria., 2023). The other researchers also commented that concrete blocks, mortar, and tools/equipment should be kept reachable to reduce unnecessary motions, whereas periodically working in sitting and standing positions will reduce the ergonomic risk of musculoskeletal disorder (Zhu et al., 2017).

In this context, the suggested worktable provides some remedies to all these. The prototype of the worktable is designed with the body balance technique and provides proper working space as per the workspace requirement at the construction site. The top of the workbench is sufficient to sit and stand, furnished with a footrest while working in a sitting position. On both sides of the top, the workbench is provided with a support plate that will help keep the materials and tools so that the masons do not need to bend (flexion) or twist while picking the materials and tools from the ground. It will also help the unskilled workers (helpers) to keep the materials without bending down to ground level. The table's minimum height is 400 mm, and it can be extended vertically up to 1200 mm height. Hence, the

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worker can efficiently perform his work from the ground level to the upper level. The workbench provides a hydraulic cylinder that can be easily operated to move the workbench top.

Conclusion

Postural evaluation of the masons while performing bricklaying and plastering work has been performed in this study. For this study, precarious working postures were selected. All these postures were evaluated using REBA, ERIN, WERA and QEC methods. A REBA, ERIN and WERA were used to evaluate postural risk level while QEC was used for exposure risk level. These methods showed that masons were at the utmost ergonomic risk level and needed immediate action for remedies.

The most exposed body parts to ergonomic risk are the shoulder, trunk, lower back and Neck. Also, the masons experience pain after a prolonged working duration. This ergonomic risk is due to working in an awkward posture, addiction, physical exhaustion and pace. Subsequently, the workbench was designed using Siemens NX 12.1 Module according to the construction site requirement after a thorough discussion with masons. This worktable will help the masons reduce the risk of neck, trunk, and lower back pain and improve their health.

Conflict of Interest

The authors declare no conflict of interest in the publication of this article.

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