

# Risk assessment of manual material handling activities (case study: PT BRS Standard Industry)

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**Abstract.** The process of moving material manually has the potential for injury to workers. The risk of injury will increase if we do not pay attention to the working conditions. The purpose of this study is to assess and analyze the injury risk level in manual handling material activity, as well as to improve the condition. The observed manual material handling activities is pole lifting and goods loading. These activities were analyzed using Job Strain Index method, Rapid Entire Body Assessment, and Chaffin's 2D Planar Static Model. The results show that most workers who perform almost all activities have a high level of risk level with the score of JSI and REBA exceeds 9 points. For some activities, the estimated compression forces in the lumbar area also exceed the standard limits of 3400 N. Concerning this condition, several suggestions for improvement were made, improving the composition of packing, improving body posture, and making guideline posters.

**Keywords:** Manual Material Handling (MMH), 2D Planar Static Model, Compression Force, Rapid Entire Body Assessment (REBA), Job Strain Index (JSI)

## 1. Introduction

Manual Material Handling (MMH) is one of the most physically demanding works due to its repetitive movements, awkward postures, contacted stresses, or forceful exertion [15]. Increased rate of musculoskeletal injuries on worker's back was reported especially injuries that caused by for work that required manual lifting/lowering, carrying, or pushing/pulling of heavy materials by laborers [8], [10], [16]. Back injuries - particular injuries to the lower back - occurred with alarming frequency [2]. Approximately, back injury is one of the most common (22% of all accidents that occurred) and most required a fee for treatment. One cause of this injury is incurred by overload force of the spine (>60%) and 60% of the overload is caused by lifting, 20% pushing or pulling goods and 20% as a result of carrying goods [15]. Occupational injuries can occur suddenly, unanticipated, and unwanted events during work leading to harm or damage to at least one part of the body [4]. Risk of injury is increased when job strength requirements exceed worker capabilities and overextension injuries are costly [6]. The injuries incurred by workers can be detrimental to both workers and industry. Workers who injured will reduce the performance of the work and the productivity of the industry. The application of ergonomic principles would help to increase performance and productivity, but mostly help a human operator to be comfortable and secure [1].

There is a considerable amount of literature on manual materials handling. Consider, for example, reference [1] is to highlight on ergonomic intervention of material handling work system in an Indian manufacturing plant, reference [15] showed that repetitive work activities, particularly involving high force, extreme joint postures, and exposure to vibration that resulted in musculoskeletal disorders, especially at the distal upper. In this literature describes how to reduce the risks that occur in the



automotive industry using the strain index, reference [3] showed that ergonomic problem not only in manual materials handling activity but also occurs in other activities such as surgery. Maintaining the same posture for a long time during surgery is one of the reasons the issue of ergonomics. Reference [5] showed that the magnitude of the compression force is influenced by posture during loads lifting. In this paper investigated three types of loads lifting. Reference [4] showed an analysis of the influences and effects of different postures performed within tasks of waste collection. While reference [8] showed analyze manual material handling working posture of the operators using 3D Static Strength Prediction Program (3DSSPP) software and to identify major areas causing long last injury of operators.

There are several studies related to manual material handling especially lifting. Some of the commonly used methods are Job Strain Index, REBA, and 2D Planar Models Methods [1], [3], [4], [5]. For this paper, those methods were applied to Indonesian workers, especially at PT BRS Standard Industry. Although the company performed frequent manual material handling activities in its daily activities, there was no investigation of lifting risk that had been done.

The study was conducted to analyze the manual material handling work system of the operators and to identify major areas causing injury of operators that related to the activities. The main purpose is to minimize the risk of operators' physical and physiological disorders caused by poor MMH system.

## 2. Methods

This research was conducted to 8 workers who perform manual handling material activity, especially the activity of lifting the pole and loading the goods. Nordic body map questionnaire was used to identify symptoms, complaints, disorder, and injuries experienced by workers. Measuring tools that used to perform data collection were the camera and the meter. Data collected included:

1. Anthropometry: height and weight, and body segment length (upper arm, forearm, and torso).
2. Joint Angles, including data related to angles of between 2 body segments or between body segment and horizontal/vertical line during work, such as legs back neck arms and wrists.
3. Material Specification, including size, type, and weight of materials to be transported.
4. Hand Loads show load received by hand.
5. The intensity of labor usage, duration, working speed, and length of work per day.
6. Worker photos and videos while performing manual material handling activities.

The next step is to perform data processing by Job Strain Index, REBA, and Chaffin's 2D Planar Static Model. Some variables needed to calculate the score on Job Strain Index Method. After JSI method, processing data was continued using REBA method.

Joint angle was determined using the measured angle from pictures that were taken during activities. Angle was measured with the help of Image Analysis in Ergofellow software. The angle values then were inputted to Upper Extremity Analysis [1] by ErgoIntellegence to perform REBA analysis.

In REBA method, assessment of operator's work posture was done to know the possibility of risks due to work postures performed by the operator. If the REBA score showed "undesired" score, then some necessary improvements were suggested.

The software of 3D SSPP is used to find out the maximum force suffered by the worker in doing such a job [4], [8]. The assessment was based on the results of Sagittal Plane Low back Analysis Compression Force on L5 / S1. If the total compression is still within the specified limit or less than 3400 N, then it can be concluded that the maximum force that has to be accepted is still acceptable for the worker's body.

For every score that beyond the specified limit, work improvement was suggested, especially to improve the work posture. Moreover, further analysis was done to estimate the requirement of supporting tool. If it was necessary, a new tool design was suggested. Suggested work posture then is re-assessed using the same posture analysis method.

### 3. Result and Discussion

Using JSI, REBA, Planar 2D Static Model, the recapitulation of the results presented in table 1:

**Table 1.** Recapitulation of result

Task	Job Strain Index Score (lower better)	REBA Score (lower better)	Compression Force (N) (lower better)
<b>Research Subject A</b>			
Pole Lifting	7.3	6	2060.5
<b>Research Subject B</b>			
As Loading - worker A	9.8	10	3729.4
As Loading - worker B	9.8	10	2548.5
As Loading - worker C	4.9	10	2457.1
Leaf Slat Loading - worker A	7.3	12	3931.4
Leaf Slat Loading - worker B	7.3	7	2602
Pole Loading- worker A	7.3	12	2660.3
Pole Loading- worker B	14.6	11	3019.5

When maximum compression force for lifting is 3400 N, for JSI and REBA, low-risk work is achieved when the score below 3. On the other hand, an activity is determined to have high risk of injury when the score is more than 7. Based on the results of table 1, almost all activities have risk levels according to JSI and REBA. The activity that has relatively high level of risk of all three methods is the activity of slat leaf removal by worker A.

Figure 1 shows worker position when he wants to take leaf slat. It can be seen that the body is bent and slightly spun. The body angle for each segment of the body is quite large, resulting in a high score. The value of the compression force obtained exceeds 3400 N, indicating that this activity is dangerous.

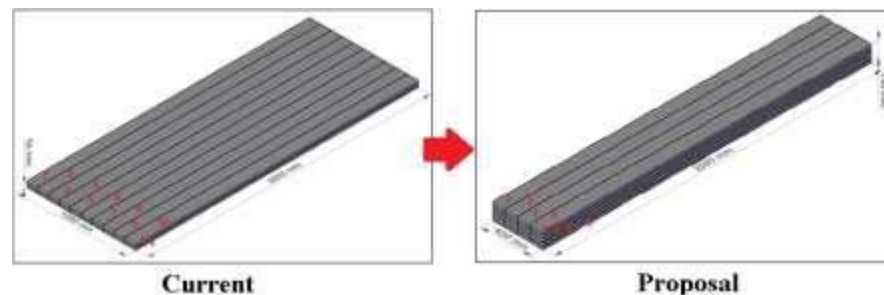


**Figure 1.** Working posture of Leaf slat loading – worker A

Based on these results, the proposed improvements are:

1. Proposed improvement by *Engineering Controls*

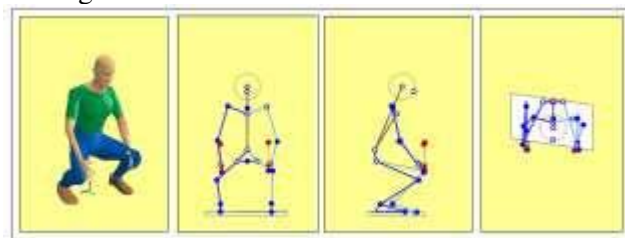
In the proposed improvement, a suggestion was made on the leaf slats packing arrangement so that the pack was easier to lift by the workers. In the current situation, 2 workers are working together to lift 1 pack of leaf slats (1 pack consists of 10 slats). However, the worker has to widely stretch out his arms to lift the edge of the pack. This overextended posture causes high risk for arms. In suggested system, Using the proposed system, 5 slats were stacked together. In one lift, a pair of workers can lift 2 or 3 packs, depend on the weights of each slat. This arrangement is safer for workers since they did not have to overextend their arms.



**Figure 2.** Proposed Leaf slat packing

## 2. Proposed Improvement by *Management Controls*

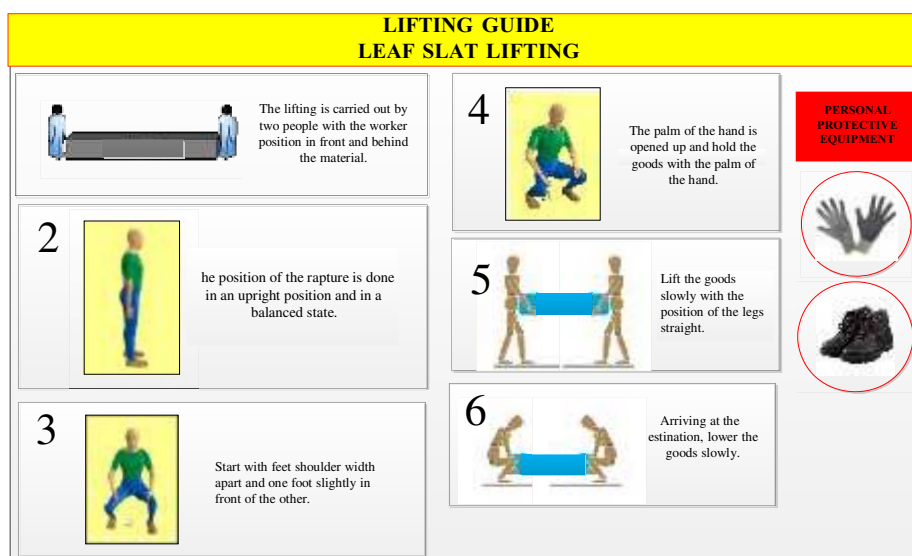
Each worker should be trained on safety working, especially in manual material handling activities. The proposed lifting position was presented in figure 3. In this position, legs should be opened wide and bent with 1 leg was slightly toward the other. Do not forget to keep maintain back in straight position. When the object was started to lift, put the objects as close to the body. If it is possible, put the object between his legs. Body move towards slightly with still keeping the back straight position and begin to lift. It is important to keep all lifting activities as smooth as possible and avoid jerk lifting.



**Figure 3.** Position of Proposed posture

## 3. Proposed Improvement by *Work Practice Controls*

It also suggested making lifting guidelines posters. The posters should be put in the area where the lifting activity occurs, in the location that can be easily seen by workers.



**Figure 4.** Example of lifting guide poster

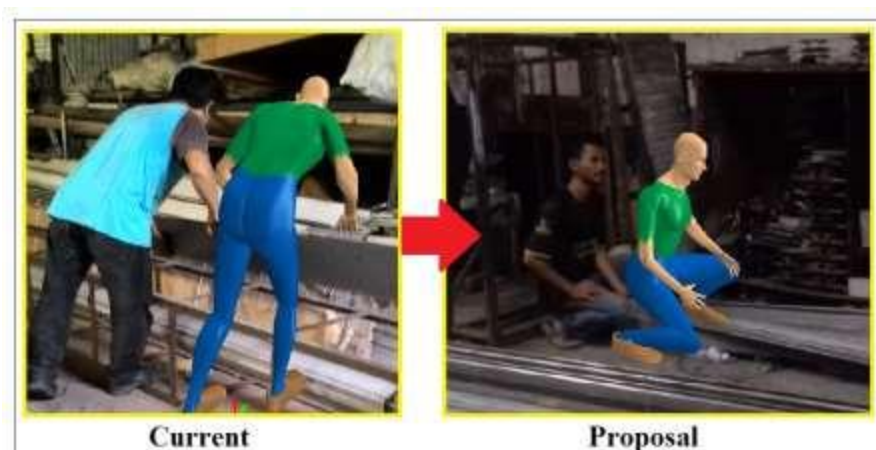
Proposed postures and improvements later were analyzed using the same methods. From table 2 it can be seen that the proposed situation reduce both times of lifting and risk level of injury.

**Table 2.** Performance comparison of current and proposed condition

Criteria	Pole Lifting		As Loading		Leaf Slat Loading		Pole Loading	
	Current	Proposal	Current	Proposal	Current	Proposal	Current	Proposal
Time of lifting (s)	21.75	16.86	17.8	12.4	13	9	13.4	9.93
Score JSI	7.3	1.5	9.8	3.375	7.3	4.5	14.6	4.5
Score REBA	6	4	10	5	12	5	12	5
Compression Force(N)	2060.5	1378	3729.4	2594	3931.4	2975	3019.5	2975

The proposed improvements were suggested for all activities. One improvement that implemented was tried is work posture changing like suggestion number 2. When the trials were conducted, workers have confusion when applying the new lifting method, often the position only persisted for some replication only and returns to its original position. However, after some repetition finally, the workers understand. Table 2 shows the comparison of value between the current situation and proposed situation score. Proposed situation score was estimated based on trials after the workers can apply new lifting and loading posture relative persistently. The results of the table show that the proposed method was able to reduce the risk of injury and shorten activity time.

Figure 5, 6, 7 show the comparison between current and proposed system. In all current methods, the main flawless is the back position. Workers tend to their back instead of their leg. Therefore, maintaining straight back position has been the main improvement. Second thing, in the current system, workers tend to perform the activity individually. Similar to lifting process in figure 6, worker lifted the slat alone by putting the slat on shoulder one by one. In the proposed system, the activities should be done by two persons, lifting 2 slats at a time. Therefore the productivity is still maintained.



**Figure 5.** Comparison of the current and proposed lifting position

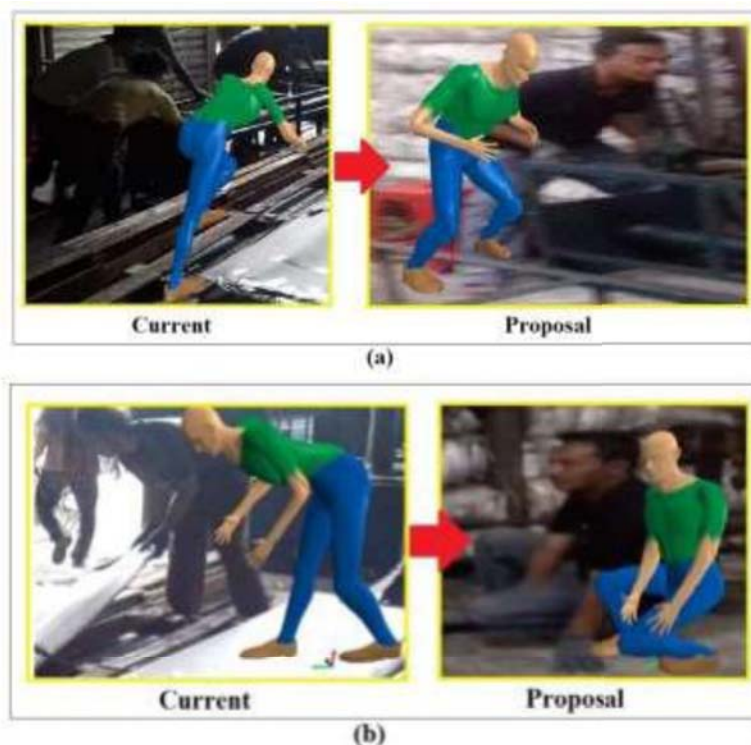
After the trials were conducted, an interview was conducted with the workers who had performed the proposed condition, where the results found that the worker felt awkward at the beginning of the new position but then felt more comfortable with the position. Workers give no complaint at the waist and shoulders. From the trial processes, it can be concluded that basically, the proposed method



improved the work qualities. However, further training is needed to make sure workers aware about the safe lifting procedure and how to apply it in their daily working activities.



**Figure 6.** Comparison of the current and proposed lifting position to pole lifting



**Figure 7.** Comparison of loading position (a) As (b) Leaf Slat and Pole

#### 4. Conclusion

Using JSI, REBA, and 2D Planar Models Methods, Manual material handling activity identify that almost all activities have high-risk levels, with the highest was found in the loading of slat leaf goods activity. Body position greatly affects the occurrence of high risk, especially the back position. There are three improvements applied to reduce the risk of injury to the activity, including improving the composition of packing, improving body posture, and making guideline posters.

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