Lecture Notes in Mechanical Engineering

B. B. V. L. Deepak
M. V. A. Raju Bahubalendruni
D. R. K. Parhi
Bibhuti Bhusan Biswal *Editors*

Recent Trends in Product Design and Intelligent Manufacturing Systems

Select Proceedings of IPDIMS 2021

Springer

Lecture Notes in Mechanical Engineering

Lecture Notes in Mechanical Engineering (LNME) publishes the latest developments in Mechanical Engineering—quickly, informally and with high quality. Original research reported in proceedings and post-proceedings represents the core of LNME. Volumes published in LNME embrace all aspects, subfields and new challenges of mechanical engineering. Topics in the series include:

- Engineering Design
- Machinery and Machine Elements
- Mechanical Structures and Stress Analysis
- Automotive Engineering
- Engine Technology
- Aerospace Technology and Astronautics
- Nanotechnology and Microengineering
- Control, Robotics, Mechatronics
- MEMS
- Theoretical and Applied Mechanics
- Dynamical Systems, Control
- Fluid Mechanics
- Engineering Thermodynamics, Heat and Mass Transfer
- Manufacturing
- Precision Engineering, Instrumentation, Measurement
- Materials Engineering
- Tribology and Surface Technology

To submit a proposal or request further information, please contact the Springer Editor of your location:

China: Ms. Ella Zhang at ella.zhang@springer.com
India: Priya Vyas at priya.vyas@springer.com
Rest of Asia, Australia, New Zealand: Swati Meherishi at swati.meherishi@springer.com
All other countries: Dr. Leontina Di Cecco at Leontina.dicecco@springer.com

To submit a proposal for a monograph, please check our Springer Tracts in Mechanical Engineering at https://link.springer.com/bookseries/11693 or contact Leontina.dicecco@springer.com

Indexed by SCOPUS. All books published in the series are submitted for consideration in Web of Science.

B. B. V. L. Deepak ·
M. V. A. Raju Bahubalendruni · D. R. K. Parhi ·
Bibhuti Bhusan Biswal
Editors

Recent Trends in Product Design and Intelligent Manufacturing Systems

Select Proceedings of IPDIMS 2021

Springer

Editors
B. B. V. L. Deepak
Department of Industrial Design
National Institute of Technology Rourkela
Rourkela, India

M. V. A. Raju Bahubalendruni
Department of Mechanical Engineering
National Institute of Technology
Puducherry, India

D. R. K. Parhi
Head Professor (HAG), Mechanical Engineering
National Institute of Technology Rourkela
Rourkela, India

Bibhuti Bhusan Biswal
Mechanical Engineering
National Institute of Technology Meghalaya
Shillong, India

ISSN 2195-4356 ISSN 2195-4364 (electronic)
Lecture Notes in Mechanical Engineering
ISBN 978-981-19-4605-9 ISBN 978-981-19-4606-6 (eBook)
https://doi.org/10.1007/978-981-19-4606-6

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

This book congregates selected research articles from the 3rd series of Innovative Product Design and Intelligent Manufacturing System (IPDIMS-2021), held at National Institute of Technology Rourkela, India. The book emphasises the recent technologies and advanced tools in the areas of product design and manufacturing technology. The main topics covered include ergonomics and human factors, UI/UX, design for 'X', Industry 4.0, smart manufacturing, advanced robotics and CAD/AM. The contents of this book are useful for academics as well as professionals working in the areas of industrial design, manufacturing, mechatronics, robotics and automation.

Reviewers

Dr. Adik Yadav, G. H. Raisoni College of Engineering and Management, Pune, India
Dr. Alisha Pradhan, University of Maryland, College Park, USA
Dr. Alok Kumar Jha, Shri Ramdeobaba College of Engineering and Management, India
Dr. Amruta Rout, Amrita School of Engineering, Bengaluru, India
Dr. Anand Amrit, Dura Automotive System, Auburn Hills, Michigan, USA
Dr. Animesh Chhotray, Gandhi Institute for Education and Technology, Baniatangi, India
Dr. B. V. Rao, Mother Teresa College of Engineering, Vizianagaram, India
Dr. Bhumeswer Patle, MIT University, Pune, India
Dr. Chinamay Sahu, VIT Campus, Vellore, India
Prof. Debashis Majumder, UPES School of Design, Dehradun, India
Prof. G. Balamurali, Vellore Institute of Technology, India
Dr. G. Ramakrishna, Godavari Institute of Science and Technology, Rajahmundry, India
Dr. Golak B. M., Karunya Institute of Technology and Sciences (Deemed University), India
Dr. H. C. Das, National Institute of Technology Meghalaya, India
Dr. Harshika Singh, Politecnico di Milano, Milano Bovisa-Via La Masa, Italy
Dr. Irshad Khan, Sagar Institute of Research and Technology, Bhopal, India
Dr. J. Bala Bhaskar, Vishnu College of Engineering, Srikakulam, India
Dr. J. Bhaskar Rao, Gayatri Collage of Engineering, Autonomous university, Visakhapatnam, India
Dr. Jammu Nalini, JNT University, Vizianagaram, India
Dr. Jayanta Kumar Pothal, CSIR-Institute of Minerals and Materials Technology
Dr. Krishna Kishore Osuri, National Institute of Technology Rourkela, India
Dr. Krishna Kr. Pandy, G. H. Raisoni Institute of Engineering and Technology, Pune, India
Dr. Manoj Kr. Muni, Indira Gandhi Institute of Technology, Sarang, India
Dr. Manu Elappila, CHRIST University, Bengaluru, India
Dr. P. C. Jena, Veer Surendra Sai University of Technology, Burla, India

Dr. Pradip Kr. Sahu, Birsa Institute of Technology, Sindri, India
Dr. Promod Parida, Government College of Engineering, Bhubaneswar, India
Dr. R. N. Mahapatra, National Institute of Technology Meghalaya, India
Dr. Ramakrishna Goddu, Krishna University, Andhra Pradesh, India
Dr. Ramu Inala, Vishnu College of Engineering, Autonomous University, Eluru, India
Dr. Sakuntala Ojha, KIT University, Warangal, India
Dr. Sampat Kr., National Institute of Technology Rourkela, India
Dr. Saroj Kumar Pradhan, CET Bhubaneswar (Government of Odisha), India
Dr. Sasmita Das, KIIT University, Bhubaneswar, India
Dr. Shakti P. Jena, Vardhaman College of Engineering, Hyderabad, India
Dr. Shrishail Hiremath, National Institute of Technology Rourkela, India
Dr. Varalakshmi K. V., Raghu College of Engineering, Visakhapatnam, India
Dr. Venkataramana Naik, National Institute of Technology Rourkela, India
Prof. Aezeden Mohamed, UNITECH University, Papua New Guinea
Prof. Anirban Chowdhury, UPES School of Design, Dehradun, India
Prof. Anish Pandey, KIIT University, Bhubaneswar, India
Prof. Bunil B. Ray, National Institute of Technology Meghalaya, India
Prof. J. C. Mohanta, Malaviya National Institute of Technology, Allahabad, India
Prof. J. Srinivas, National Institute of Technology Rourkela, India
Prof. K. Satyababu, National Institute of Technology Rourkela, India
Prof. Om Prakash Sahu, Vellore Institute of Technology, India
Prof. P. K. Jena, Veer Surendra Sai University of Technology, Burla, India
Prof. P. K. Mohonty, National Institute of Technology Arunachal Pradesh, India
Prof. R. Gujjala, National Institute of Technology Warangal, India
Prof. S. Gopalkrishna, National Institute of Technology Rourkela, India
Prof. S. Kundu, KIIT University, Bhubaneswar, India
Prof. D. S. Bisht, National Institute of Technology Rourkela, India

Contents

Product Design: UI/UX

Intelligent Manufacturing Systems: Advanced Manufacturing Processes

About the Editors

Dr. B. B. V. L. Deepak is currently working in the Department of Industrial Design at National Institute of Technology (NIT) Rourkela. He received his Master's and Ph.D. degrees from the NIT Rourkela in 2010 and 2015, respectively. He has 11 years of research and teaching experience in manufacturing and product design fields. He has produced 3 Ph.D. theses and is currently supervising 4 Ph.D. scholars. He has published over 100 papers in various peer-reviewed journals and conferences and holds one patent in his name. He is also currently handling two sponsored research projects in the field of robotics. He received several national and international awards such as Ganesh Mishra Memorial Award-2019, IEI Young Engineer Award-2018, Early Career Research Award-2017, etc.

Dr. M. V. A. Raju Bahubalendruni is currently working as Assistant Professor in the Department of Mechanical engineering at National Institute of Technology (NIT) Puducherry, India. He completed his masters in machine design at Andhra University College of Engineering, India. He has industry experience having worked on several aircraft programmes like c27J, Bombardier, Honda Jet, Bell -407. He completed his Ph.D. degree from NIT Rourkela. He is an active researcher in the manufacturing and automation domain (assembly, disassembly, industrial robotics, human-robot collaboration, additive manufacturing, topology optimization, advanced cellular structures, augmented reality/virtual reality). He has over 11 years of total academic, industrial and R&D experience. He has received multiple research grants from Science and Engineering Research Board (SERB), Department of Science and Technology (DST). He has published close to 80 articles in reputed national and international journals. He has been awarded with Gold Medal "BRUNDABANSAHU MEMORIAL AWARD" by Institute of Engineers India (IEI-Odisha) in 2016 for his research contribution, received National level (Indian) Young Engineer award 2017 in the mechanical stream by IEI.

Prof. D. R. K. Parhi is working at National Institute of Technology (NIT) Rourkela as a Professor. He is currently heading the Department of Mechanical Engineering. He received his Ph.D. in Mobile Robotics field from Cardiff School of Engineering, UK. He has 26 years of research and teaching experience in robotics and artificial intelligence fields. He has guided more than 20 Ph.D. theses and published more than 300 papers in various journals and conferences and holds 3 patents in his name. He has also completed and currently handling several sponsored research projects in the field of robotics.

Prof. Bibhuti Bhusan Biswal is currently acting as Director of National Institute of Technology (NIT) Meghalaya. He is also a Professor (HAG) in the Department of Industrial Design of NIT Rourkela. He has 33 years of research and teaching experience in FMS, CAD/CAM, and robotics. He has guided more than 15 Ph.D. theses and published more than 200 papers in various journals and conferences along with 3 patents/copyrights. He has international collaboration with Loughborough University and Slovak University of Technology in Bratislava. He has also completed and currently handling several sponsored research projects in his research field.

Product Design: Ergonomics and Human Factors

Analysis of Secondary Tasks Performed and Psychosocial Factors of Railway Loco Pilots

Suyash Krishna, Sangeeta Pandit, Rajat Kamble, and Jigyasa Hemant Patankar

1 Introduction

Indian Railway system occupies the first railway network system in Asia and is fourth largest in the world [1]. It is 167 years old and comprises 436 departments and 15.4 lakh employees working [1]. Indian Railway is the fourth largest Railway track network in the world [1]. It has a total of about 108,706 route-kms of track which covers 6853 stations [1]. Indian Railways runs 11,000 trains daily, consisting of passenger and goods trains [1]. This Indian transportation system handles 13 million passengers and 1.35 million tonnes of freight with a total of 11,000 trains on a daily basis [1]. Indian Railways is considered to be one of the safest and comfortable means of transportation for both man and material.

A study report on railway drivers found a higher incidence of stress compared to other jobs like assistant station masters, train examiners and office clerks [2]. Loco pilots get irregular sleeps and suffer stress-related diseases like hypertension, diabetes and frequent headaches [3]. The loco pilot of a high-speed train has to work for 400–500 km at a stretch without any food or toilet break. The driver of a high-speed train like Rajdhani has to observe a signal every 1 min 22 s on average, which means he has to be vigilant continuously [3]. The loco pilots operating at a long-distance route stay overnight in the running room away from the home station [3]. The night duty is only considered when the duty is between 10 pm and 6 am [3]. There is a high noise level in the cab which has adverse effects on the mind and ears of the drivers [3]. During hot summer days, the cab temperature goes as high as 54–56 °C [3]. Poor visibility due to foggy or rainy weather or sometimes because of not proper functioning of the wiper is often faced by the loco pilots. The workspace

S. Krishna · S. Pandit (✉) · R. Kamble · J. H. Patankar
Ergonomics Lab, Design Discipline, PDPM Indian Institute of Information Technology, Design and Manufacturing, Jabalpur, Madhya Pradesh 482005, India
e-mail: s.pandit@iiitdmj.ac.in

B. B. V. L. Deepak et al. (eds.), *Recent Trends in Product Design and Intelligent Manufacturing Systems*, Lecture Notes in Mechanical Engineering,
https://doi.org/10.1007/978-981-19-4606-6_1

Fig. 1 Inside cab of WAG 12 locomotive

of a locomotive cab drivers is usually with seats without backrest and without toilet and pantry (Fig. 1). Presently, the work schedule of Loco Pilots is classified under 'continuous' roaster, which results in no fixed calendar off-day. In usual cases, the loco pilots must work for continuous 10 h duty and can take break after 12 h by giving notice to the controller [4]. Loco pilots do not have control on their work environment and often need to work with job schedules that disturb their personal life and social life, and planning leaves is also difficult [5].

Over the years, many research studies concerning the psychological effects, work-life balance, stress and fatigue, ergonomics and health effects of the loco pilots have been done [3, 5–8]. There is a need for analysis of the tasks they perform and psychosocial factors related to the duty of the loco pilots. The tasks taken here are secondary tasks performed by the Loco pilots for the smooth running of the train [6]. The secondary task is subdivided as blowing horn, operating vigilance switch—button to keep a check on alertness, use of walkie talky—verbal communication with the crew, signal exchange—to exchange speechless communication and leaning out—to check on the following train attached at the rear end visually [6]. Psychosocial factors are to understand the social conditions of the loco pilots, which affect mental health. The study aims to find out the tasks performed and psychosocial effects on the various designation levels of the Loco pilots.

2 Methodology

The study was conducted at Patna Junction. Patna Junction is one of the busiest railway stations in the country [9]. Patna Junction is operated by East Central Railways, and it lies on the busiest railway route, New Delhi to Kolkata.

There are some limitations in conducting this study due to the COVID situation resulting in a smaller number of respondents participating in the study. In this study, 38 respondents of different designations working in the Danapur division in Patna participated. All the respondents were randomly chosen and participated voluntarily. Among the total 38 respondents, all were male. The primary data source was collected through a self-administered questionnaire that was designed keeping in mind the objectives of the study. The self-administered questionnaire contained questions addressing the secondary tasks performed by the Loco pilots based on the study done by Subir Danda [6], and the questions related to psychosocial factors which they go through were based on the research findings [5, 7].

Total of 17 questions were generated based on the findings of the study [5–7]. Out of which, 5 questions addressed the physical factors of the Loco pilots and the rest 12 questions addressed psychosocial factors. The questionnaire was prepared for psychosocial factors like no job satisfaction, support from the co-pilots and supervisor, work health hazard anxiety, difficulty in relaxing, demand for hiding emotion, depression, responsibility of people, missing on quality family time, work overload, time pressure and no fixed working hours. Furthermore, the questionnaire was prepared for tasks like blowing horn, operating vigilance switch, using walkie talky, signal exchange and leaning out. The questions asked were as follows: 'How often in your work you Q1: are not satisfied with your job?; Q2: get support from Co-pilots?; Q3: get support from supervisors?; Q4: feel anxiety because of work related health hazard?; Q5: face difficulties to relax during relax hours?; Q6: have to hide your emotions?; Q7: feel like depression?; Q8: feel responsibility of people?; Q9: miss out quality time with family?; Q10: get overloaded with work?; Q11: get time pressure?; Q12: get uncertain working hours?; Q13: perform task of Blowing horn?; Q14: perform task of operating vigilance switch?; Q15: use walkie talky?; Q16: perform exchange of signals?; and Q17: lean out?'. The questions were to be answered in a 5-point scale. The 5-point scale used was as follows: 1 signifies rarely, 2 signifies rather rarely, 3 signifies sometimes, 4 signifies rather often, and 5 denotes often. Finally, the respondents were asked to rate each of the tasks and factors on the above scale. The answer ratings 1 and 2 were classified as 'No', and ratings 3, 4 and 5 were classified as 'Yes'.

For statistical analysis, basic statistics, including total mean and percentages, were calculated. The statistical differences between the various designation levels, psychosocial factors and tasks were found using the chi-square test. Here, $p < 0.001$ is being considered statistically highly significant, and $p < 0.05$ is being considered statistically significant throughout the study.

Table 1 Demographic data of survey participants

Gender	Male	38 (100%)
	Female	0
Designation	ALP	8 (21%)
	ALP goods	10 (26.3%)
	ALP passenger	6 (15.7%)
	LP goods	5 (13.1%)
	LP passenger	4 (10.5%)
	LP mail	5 (13.1%)
Marital status	Married	33 (66.7%)
	Unmarried	5 (33.3%)

3 Results

3.1 Demographic Profile

Among the total 38 respondents, all are men (Table 1). The respondents are from the 18–62 years of age groups and across all the designations of the Loco pilots. Asst Loco pilots (ALP) were 8, Asst Loco pilot goods (ALP goods) were 10, Asst Loco pilot passengers (ALP passengers) were 6, Loco pilot goods (LP goods) were 5, Loco pilot passengers (LP passengers) were 4, and Loco pilot mail (LP mail) was 5, respectively. Respondents were mostly the pilots of goods trains (23 out of 38), and the rest (15 out of 38) were of mail (passenger) trains. All the respondents belong to Patna Jn, which is under the Danapur division of Indian Railways.

3.2 Psychosocial Factors Affecting Loco Pilots

Table 2 shows the psychosocial factors which affect the Loco pilots across the levels of designation based in Patna Jn. The statistical differences among the different demographic groups were found to be insignificant for the psychosocial factors: support from co-pilots, support from supervisors, responsibility for people and missing family time. This suggested that all the above factors are prevalent across all levels of loco pilots. There was significant low job satisfaction among the Asst Loco pilots as compared to the Loco Pilots. In addition, there was a significant difference found in working health hazard anxiety ($p < 0.05$). Loco pilots with higher designations tend to have more anxiety of getting any health issues/hazards due to their duty. For the psychosocial factor: demand of hiding emotions and depression, there was a significant difference compared to higher and lower designation levels. Lower-level loco pilots tend to have high depression levels ($p < 0.05$), and they hide their emotions more ($p < 0.05$). Under no fixed working hours ($p < 0.001$), it was found that Loco

pilots with higher designation levels tend to have fixed working hours compared to lower designation levels.

3.3 Secondary Tasks Affecting Loco Pilots

Table 3 shows the tasks which affects the Loco pilots across the levels of designation based in Patna Jn. The statistical differences among the different demographic groups were found to be insignificant for the task: signal exchange. For the tasks: blowing horn and operating vigilance switch, there was a significant difference when compared to higher and lower designation levels. Higher-level loco pilots tend to blow horn ($p < 0.001$) and operate vigilance switch ($p < 0.001$) more as compared to lower designation levels. There was a significant difference found when it comes to use of walkie talky ($p < 0.05$). Loco pilots with lower designation levels tend to have more use of walkie talky. For leaning out tasks, there was a significant difference ($p < 0.001$) when compared across the levels of loco pilot. Loco pilots with lower designation levels tend to lean out more as compared to higher levels.

4 Discussion

In this study, we found that Loco Pilots with higher designation levels have more job satisfaction as compared to lower levels. Loco Pilots with higher designation levels experienced lower workload pressure as compared to others. The anxiety of health hazards related to work was found to have more with the Loco pilots as compared to Asst Loco pilots. It was also found that high designation Loco pilots feel uneasy about relaxing and sleeping during relaxing hours as compared to Asst Loco pilots. Quality family time is compromised across all levels of designation of Loco pilots. Similar studies have been done related to the work and life of the Loco pilots [5, 8]. Signs of depression were found to have with Asst Loco Pilots, and they also tend to hide their emotions during duty hours. Similar studies found in the research paper [5] suggested that the job demands lead to affect the mental health of the Loco pilots. It was found that there were no fixed hours of working for the Loco pilots. This was discussed in the previous research papers [10]. Loco pilots can be allotted any shift of duty, and number of working hours depends upon circumstances.

It was also found that tasks like use of walkie talky, signal exchange and leaning out were frequently seen among ALP, ALP goods and ALP passenger. And the tasks like blowing horn, operating vigilance switch and also signal exchange were most frequent among designations like LP goods, LP passenger and LP mail. These tasks are found to cause musculoskeletal disorders among the Loco pilots [6]. In the study done by Subir danda and Soumya Sarkar, the RULA score for the tasks like blowing horn, operating vigilance switch, use of walkie talky and leaning out was found to be 3–4 [6], which suggested that ergonomic intervention may be required

Table 2 Designation levels with respect to psychosocial factors of loco pilots

Designation	No job satisfaction		Support from co-pilots		Support from supervisors		Work health hazard anxiety		Difficulties to relax during relax hours		Demands for hiding emotions	
	N (%)	*P* value	*N* (%)	*P* value	*N* (%)	*P* value	*N* (%)	P value	*N* (%)	*P* value	*N* (%)	*P* value
ALP	7 (87.5)	0.006*	7 (87.5)	–	7 (87.5)	–	2 (25)	0.04*	3 (37.5)	0.015*	8 (100)	0.038*
ALP goods	10 (100)		9 (90)		9 (90)		5 (50)		7 (70)		10 (100)	
ALP passenger	5 (83.3)		6 (100)		6 (100)		3 (50)		6 (100)		6 (100)	
LP goods	3 (60)		4 (80)		5 (100)		4 (80)		5 (100)		4 (80)	
LP passenger	1 (25)		4 (100)		4 (100)		4 (100)		4 (100)		2 (50)	
LP mail	1 (20)		5 (100)		5 (100)		5 (100)		5 (100)		3 (60)	
Designation	Depression		Responsibility for people		Missing quality family time		Work overload		Time pressures		No fixed working hours	
	N (%)	*P* Value	*N* (%)	*P* Value	*N* (%)	*P* Value	*N* (%)	*P* value	*N* (%)	*P* value	*N* (%)	*P* value
ALP	6 (75)	0.02*	8 (100)	–	8 (100)	–	8 (100)	0.02*	8 (100)	0.015*	8 (100)	0.000**
ALP goods	8 (80)		7 (70)		10 (100)		9 (90)		10 (100)		10 (100)	
ALP passenger	3 (50)		6 (100)		6 (100)		6 (100)		6 (100)		4 (66.7)	
LP goods	1 (20)		2 (40)		5 (100)		5 (100)		1 (20)		5 (100)	
LP passenger	1 (25)		2 (50)		4 (100)		1 (25)		1 (25)		0 (0)	
LP mail	0 (0)		4 (80)		5 (100)		2 (40)		1 (20)		0 (0)	

* indicates $p < 0.05$, and ** indicates $p < 0.001$

Table 3 Designation levels with respect to secondary tasks of loco pilots

Designation	Blowing horn		Operating vigilance switch		Use of walkie talky		Signal exchange		Leaning out	
	N (%)	*P* Value	*N* (%)	*P* Value	*N* (%)	*P* Value	*N* (%)	*P* Value	*N* (%)	*P* Value
ALP	1 (12.5)	0.000**	0 (0)	0.000**	7 (87.5)	0.001*	8 (100)	–	8 (100)	0.000**
ALP goods	2 (20)		0 (0)		10 (100)		10 (100)		10 (100)	
ALP passenger	6 (100)		0 (0)		6 (100)		6 (100)		5 (83.3)	
LP goods	5 (100)		5 (100)		2 (40)		5 (100)		3 (60)	
LP passenger	4 (100)		4 (100)		1 (25)		3 (75)		0 (0)	
LP mail	5 (100)		5 (100)		1 (20)		4 (80)		0 (0)	

* indicates $p < 0.05$, and ** indicates $p < 0.001$

for these tasks. Furthermore, task like signal exchange which was the most frequent and repeating task across the designations such as ALP (100%), ALP goods (100%), ALP passenger (100%), LP goods (100%), LP passenger (75%) and LP mail (80%) had RULA score of 5 [6], which suggested ergonomic interventions should be done soon.

Limitations of this study are the smaller number of respondents considered for the study due to the pandemic situation. Therefore, larger data could help better understanding in this area of research.

5 Conclusion

Loco pilots are one of the important crew members responsible for the safety of the train by avoiding any accidents. It is important to understand the working conditions and their mindsets across all the levels of the designations of Loco pilot. The research shows that various psychosocial factors, like job satisfaction, work health hazard anxiety, no proper sleep, depression, work pressure, no fixed hours of duty, etc., are different across the higher and lower designation levels of the Loco pilots. To improve the conditions of Loco pilots, the above problems need to be analysed and dealt with at the hierarchy level of the Loco pilots. Some factors like lack of quality time with family, support from the crew members and feeling of responsibility are consistent across all the designation levels of the Loco pilots, which can also be dealt with to improve their working conditions. Higher designation level Loco pilots perform secondary tasks: blowing horn, signal exchange and operating the vigilance switch. This research can help to understand the tasks performed and task-related psychosocial issues of the Loco Pilots.

References

1. Indian Railways homepage: https://indianrailways.gov.in/, last accessed 18 Oct 2021
2. Kumar, D., Singh, J.V., Kharwar, P.S.: Study of occupational stress among railway engine pilots. Indian J. Occup. Environ. Med. **15**(1), 25 (2011)
3. Ranjan, R., Prasad, T.: Work-life of Indian railway's drivers (loco-pilots). IOSR J. Bus Manag. **9**(2), 39–48 (2013)
4. Kant, S.R.: Life of an Assistant Loco Pilot (ALP)/Assistant Driver. All India Loco Running (2008)
5. Ranjan, R., Prasad, T.: Job Demands And Its Effects On Health: A Study on Indian Loco-Pilots (Railway Drivers). IOSR JHSS (2017)
6. Danda, S., Sarkar, S., Bepari, B., Saha, K., Lahiri, B.N.: Ergonomic assessment of secondary task performed by Indian Railways Loco Pilots (2019)
7. Ranjan, R., Prasad, T.: Working-conditions, stress and their outcomes: a review study among loco-pilots (railway drivers) in India (2014)
8. Joy, M., Krishna, M. A. R.: Family environment, emotional regulation and job stress among loco pilots of Indian Railway (2020)

9. Patna Junction railway station: https://en.wikipedia.org/wiki/Patna_Junction_railway_station. Accessed 15 Oct 2021
10. Ranjan, R., Prasad, T.: Work-Life Balance of Loco Pilots. IOSR (2016)

Instructions for the Preparation Intervention of Shoulder Load Carrier for Porters Working in Vegetable Mandi of Jabalpur

Sangeeta Pandit, Rajat Kamble, Avinash Sahu, Bangaru Sai Prakash, and Vishal Patil

1 Introduction

Manual material handling (MMH) is human act of lifting, lowering, pushing, pulling, carrying, holding, and releasing items. In India, due to the chief labor force, MMH is a major part of material handling activity in different transportation sectors [1, 2]. One such MMH activity is found by the porters in the fruits and vegetable wholesale markets commonly known as "sabji mandi". The porters of any wholesale markets are the backbone of transportation of goods between truck and shops of a mandi. MMH exposes workers to physical risk factors. If these tasks are performed repeatedly or for a longer period of time, it can cause injuries. Main risk factors associated with the development of injuries in MMH tasks include uncomfortable postures, repetitive actions, forceful exertions, loads. The present study was led in the main wholesale vegetable and fruit markets of Jabalpur from where the fruits and vegetables were supplied to different local markets. Around 300 tons of fresh vegetables and fruits are distributed daily throughout Jabalpur city. To keep the mandi running in the early morning peak business hours, around 150 porters were involved. The porters do not follow any standard ergonomic guidelines for lifting heavy weights, and the nature of work is highly repetitive in nature. In order to earn more, during the peak hours, they carry more weights without intervals. The nature of work is highly repetitive. In order to unload the trucks, the porters carry heavy load on their heads from trucks to the shops. This causes stress in the muscles, tendons, and ligaments. This high stress led to work-related injuries and health problems among the porters resulting early retirement and financial burden on the family and society. Manual load transportation is an occupation pursued by a good population of labor forces from economically

S. Pandit (✉) · R. Kamble · A. Sahu · B. S. Prakash · V. Patil
Design Discipline, PDPM Indian Institute of Information Technology, Design and Manufacturing, Jabalpur, Madhya Pradesh 482005, India
e-mail: s.pandit@iiitdmj.ac.in

B. B. V. L. Deepak et al. (eds.), *Recent Trends in Product Design and Intelligent Manufacturing Systems*, Lecture Notes in Mechanical Engineering,
https://doi.org/10.1007/978-981-19-4606-6_2