A Review of Escalator Accidents and Preclusion

Dhanasekaran R
Professor
Department of Mechanical Engineering
Guru Nanak Institute of Technology, Hyderabad, India

Vinothkanna R
Professor
Department of Electrical and Electronics Engineering
Guru Nanak Institute of Technology, Hyderabad, India

Sreenatha Reddy S
Professor and Principal
Guru Nanak Institute of Technology, Hyderabad, India

Narendra Kumar M
Professor and Vice Principal
Guru Nanak Institute of Technology, Hyderabad, India

Bala Arogya Kalyan P
UG Student
Department of Mechanical Engineering
Guru Nanak Institute of Technology, Hyderabad, India

Abstract

The study in this paper describes retrospective view of the escalator accidents. It also deals with the epidemiology of escalator allied injuries among adults and even in children from the delineation of Consumer Product Safety Commission (CPSC) and National Electronic Injury Surveillance System (NEISS). Invention of escalators has facilitated the travel of passengers in large number. It strengthened the power of technology at the same time it frightened the pedestrians, remembering that it is dangerous if it is used in a careless manner. Work in this paper gives a clear cut view of the escalator linked accidents, preventive measures required to overcome the fear called "escalator-accident". This paper also gives the classification of the escalator accidents in terms of age groups of the people using escalators and also in terms of escalator correlated injuries. It also describes the percentage distribution of the accidents among different age grouped people. CPSC has found that the escalator implicated accidents are more in number than those compared with that of the elevator related accidents. Escalator linked injuries occur more frequently and this frequency of occurrence results in significant trauma.

Keywords- Escalator; Accidents; Children; Elders; Preclusion

I. INTRODUCTION

With the development of science and technology, in the years many new inventions and discoveries had been made and such an invention which was a revelation in the transport of passengers from one stage to another in large numbers when compared to those of elevators which were already in practice. An escalator is a type of vertical transportation in the form of a moving staircase – a conveyor transport device for carrying people between floors of a building [1]. The device consists of a motor-driven chain of individually linked steps that move up or down on tracks, allowing the step trends to remain horizontal.

After a several years of research and development escalator has become a mature product and it is now used in almost all the parts of the world, in developed and developing countries to carry people from one level to another. Escalator, because of its capability of carrying large number of people compared to that of the escalator finds its use in almost all the public concentrated environments [4]. Escalators are used around the world to move pedestrian traffic in places where elevators would be impractical. Principal areas of usage include department stores, shopping malls, airports, transient system, hotels, stadiums and public buildings [2].

Below are given (Table 1) some of the main components and their functions in the escalator system

Table 1: Components of Escalators and its functions

Name of the subsystem	*Main function*	*Main components which are involved in the system*
Ladder system	*Used for supporting the load passed from the main wheel and auxiliary wheel, in order to prevent the deviation, etc*	*Stairs and driving components*
Driving system	*Driving devices is the power source of the escalator*	*Electromotor, speed bumps, brake and transmission link*
Guard rail system	*Keep balance of the escalator*	*Driving system of handrail*
Comb plate	*Its main function is to prevent injuries to the people riding on the escalator and damage their clothing and belongings*	*Broach, comb plate and front plate*
Girder	*It is useful to bear or support the weight of steel or any other material used for the escalators*	*Lower chord, top chord and web members*
Electric system	*For the control of the escalator*	*Electrical control system*

II. ESCALATOR ACCIDENTS

A word called "escalator accident", it is generally referred to accidents which involves injury of hands and feet. Escalators carry much number of people from one floor to another. During this transport of people on the escalators, many accidents occur which may even eventually lead to death [3,6]. From a detailed study, the Consumer Product Safety Commission (CPSC) estimated an average of 5900 hospital emergency-room-treated injuries associated with escalator search year between1990 and1994. Seventy-five percent of these injuries are due to falls, another 17% occur when body parts or shoes are caught in escalators and the remaining 8% are made up of lacerations and twisted ankles. Almost 20% of the injuries were to children under 5 years of age and approximately 30% of the injuries were to people over 65 years of age. The caught in the escalator (entrapment) accidents generally resulted in more serious injuries than did falls [8].

III. COMMON CAUSES

Escalator accidents are due as falls, not holding the hand rail, entrapment and cutting [8]. Among these major and most common cause of an escalator is due to "fall". Fall, it means losing balance and collapsing from the aisle of an escalator. They are most common in children and also in adults aged above 60 [7]. According to CPSC 75% of the escalator related accidents were only due to falls. These kinds of accidents occur due the playful nature of children and in adults, due to loss of balance on the escalator [5].

While on the other hand stepping off the escalator is also having some of its contribution to escalator accidents. It is most common in children; they remain standing on the escalator and try to slip of instead of stepping out from the escalator. This results in the entrapment of their little feet in the gap where the last plate slides into the comb plate [2].

IV. SAFETY PRECAUTIONS

A. When Entering Escalators

Watch the direction of the moving step and step on and off with extra care while stepping on the escalator be careful with children, don't forget to hold them firmly. Always remember to have on arm on the handrail, it means that keeps no baggage in one arm and leaves it free. Stepping on the escalator immediately needs grasping the handle firmly and carefully step onto an escalator watching the direction it is moving. Wheelchairs, electric scooters, strollers, hand carts, luggage carts or similar items shouldn't be carried on the escalator [18].

B. When Riding Escalators

Keep loose clothing clear of steps and sides and try to wear closed-toed and hard-soled shoes and avoid wearing footwear made of soft-resin or other rubbery materials Remember to Stand clear of the sides of the escalator and face forward and keep firm grip on the handrail. Reposition hand slowly if the handrail moves ahead or behind the steps. Major escalator accidents occur for the people aged below 10 years, so see that children doesn't sit on steps or stand too close to sides.

C. When Exiting Escalators

Don't hesitate and step off promptly. Be careful and make sure to step over the comb fingers; don't let feet slide off the end of the escalator. Immediately move clear of the escalator exit area; don't stop to talk or look around since other passengers may be waiting behind [16].

V. CLASSIFICATION AND EXPLANATION

Escalator injuries are categorized into five types: (i) soft tissue injuries (ii) fracture (iii) laceration (iv) closed head injuries and (v) others. Others in the sense it means that the injuries that resulted in burns, cardiac, complete body trauma [6]. This in turn again the injured body parts were classified into seven: (1) head (2) shoulder (3) upper extremity (4) torso means neck, trunk, pelvis (5) hip (6) lower extremity (7) others. Many people have become the victims of these escalator related injuries [10].

Escalator accidents are common in almost all the age groups. Among these age groups, children and older people share a major percentage. From a recent study of [5], Twenty-six children were involved in escalator-related injuries. The average age of these children was 6 years and below 4 years of age there were 13 children, it means almost 50%. All the children who were 7 years and younger was accompanied by a guardian. Among whom only 50% were holding their guardian. 31% that is 8 children were victims due to their improper riding of the escalator. 6 children (23%) of the children were injured while stepping off the escalator. Only 7 children were riding the escalator in a proper manner. Among these escalator accidents 81% of the accidents occurred in Sub-Stations [5].

Fig. 1: Injury rate per year

On the other hand even adults become victims of these escalator accidents. There were an estimated 39,850 escalator related injuries among adults of age 65 and older people till 2005. Among average there were 2660 escalator accidents per year among adults. And also many escalator related accidents are seen even among women. The main cause of women for such injuries is there dressing style. Mainly in India women were sarees and this result in entrapment of clothes and leads to injuries. The average age of adults resulting in escalator accidents was 80:1. Among the escalator related injuries 92% of the escalator accidents are treated. Among these 60% were fractures, 20% soft tissue injury and lacerations, 20% closed head injuries and less than 1% were others [10].

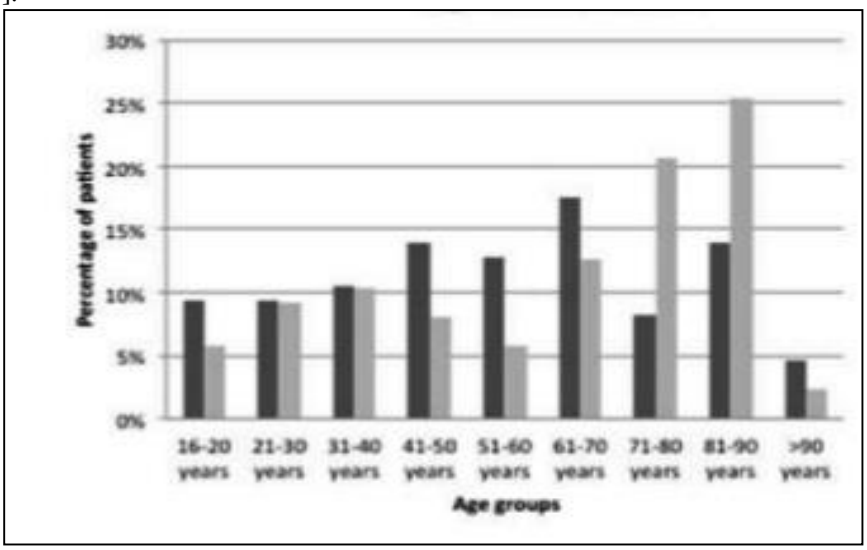

Fig. 2: Injury rate based on age groups

VI. PREVENTION OF ESCALATOR ACCIDENTS

Prevention of these escalator accidents is most and a must factor for the human friendly use of the escalators. Initially before concentrating on prevention we have to concentrate on the cause of the escalator accidents. We have to first identify, analyse and then go for the control of that risk [12].

In the analysis part, firstly study on the physical state of the escalator is important. It includes the physical state of escalator such as system's structure, physical state of the system and its subsystems of staircase and so on. It also includes the geometry, material used for the installation of the escalator, its design to reduce risks for the pedestrians and some other factors [14]. After the scrutinization of such factors its behavior and management also should be noted. Now the risk identification had to be done. The whole process has to be done as an investigation on a criminal case. On the basis of risk identification, qualitative and quantitative analysis of risk factors and the risk of loss that caused the risk events, are assed. After risk identification, risk analysis, risk assessment, we know more about the projects or system risk and its gap with risk management objectives and find the problems needed to be solved in order to ensure the security of life [9]. According to risk analysis, control measures should be taken for the prevention of such risks.

Most of the risks that cause the escalator related injuries involve entrapment between the gaps to the side of the steps. Reducing this gap controls the frequency of occurrence of these types of accidents [17]. American Society of Mechanical Engineers (ASME) recommended that the gap should be maintained as 3/16" (4.8 mm)wide, but the Taipei Rapid Transit System had further reduced it to 1/16" (1.6 mm) wide [11]. Image below gives a clear idea of gap to the sides of the steps:

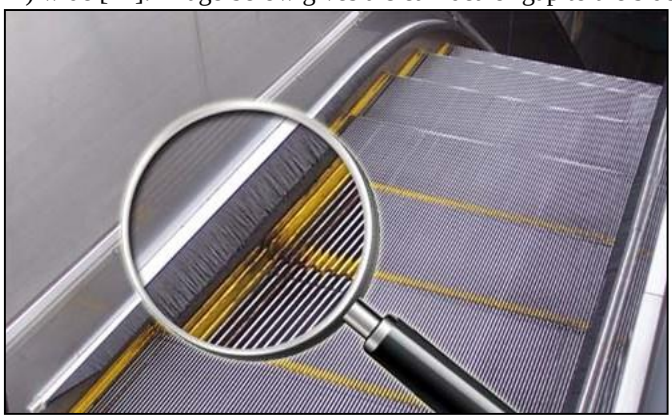

Fig. 3: Gaps between handrails and escalators

The Taipei Rapid System uses a combination of brush guard and gap of 1/16" to overcome the risk. It also claims that many of the risks due to entrapment had fallen from 16-20% to 5.7% [11].

Fig. 4: Gaps filled with brushes

The direction of the escalator must be known. This can be made clear by installing boards that shows the direction of the escalator, so that the passengers who climb the escalators will be aware of the direction of the escalator in which it is moving [13].

At the escalator junction voice service has to be installed to direct the passengers [15]. Children share a larger percent of injuries than those of adults. Parents should concentrate on the behavior of their children while riding the escalator. Children must be tightly held by the parents such that they do not run on the steps of the escalators. Also baby strollers should also be avoided [19].

Fig. 5: Caution Boards

The owners use the volunteers at the site of escalators to caution the passengers about the injuries and accidents that occur due to the carelessness of the pedestrians [20]. The staff and the volunteers should be trained in escalator safety. This training should be focused on how to meet the need of the passengers, how to assist the passengers involved in the accident. They should also know on how to locate and operate the emergency buttons, what to do in case of any accident that had occurred and what information to be given to the investigators [19].

VII. CONCLUSION

Escalators have been designed to make the travel from one stage to another stage much easier. It has been developed as an answer to carry large number of people. It has been brought into force to simplify the travel of the passengers. But in present what's happening is totally different. They are becoming the transport between life and death, but not between one floors to another. This has to be changed. Gait Recognition System can be used to identify elder people and children based on their walking style to avoid accidents. One simple sentence to conclude is "use escalator in a human friendly manner".

REFERENCES

[1] Choovoravech N, Choovoravech P, "Escalator injuries in Thai children", Journal of the Medical Association of Thailand, Vol. 58, pp. 442-444, 1975.
[2] A. De Almeida et al. “Energy-efficient elevators and escalators in Europe: An analysis of energy efficiency potentials and policy measures”, Energy and Buildings, vol. 47, pp. 151-158, 2012.
[3] N. L. Zhang, C. Liu, et al., "Technology of Risk Analysis". Xi’an: Xi'an University of Electronic Science and Technology Press, 2007.
[4] S. F. Lin, J. Y. Chen and H. X. Chao, "Estimation of number of people in crowded scenes using perspective transformation”, Systems, Man and Cybernetics, Part A, IEEE Transactions, Vol. 31, No. 6, pp. 645–654, 2001.
[5] McGeehan, Jennifer; Shields, Brenda J; Wilkins III, JR; Ferketich, Amy K and Smith, Gary A, "Escalator-Related Injuries Among Children in the United States, 1990-2002 Pediatrics, Vol. 118, No. 2, 2006.
[6] Wei Wang, Xuan Li, Qun-Li Pan, "Risk Management Based on The Escalator Overturned Accident", International Conference on Quality, Reliability, Risk, Maintenance and Safety Engineering (QR2MSE), 2013.
[7] Platt, Shari L; Fine, Jeffery S and Foltin, George L, "Escalator-related Injuries in Children", Pediatrics, Vol. 100, No. 2, 1997.
[8] Chia-Fen Chi, Tin-Chang Chang, Chi-Lin Tsou, "In-depth investigation of escalator riding accidents in heavy capacity MRT stations", Accident analysis and Prevention, Vol. 38, No. 4, pp. 662-670, 2006.
[9] Joseph O’Neil, Gregory K. Steel, Carrie Huisingh, Gary A. Smith, "Escalator-related injuries among older adults in the United States 1991–2005", Accident, Analysis and Prevention, Vol. 40, No. 2, pp. 527-533, 2008.
[10] Kazuhiro Hirota, Shogo Namatame, and Nobuto Matsuhira,“Development of an escalator riding robot: Experiment of riding on an up escalator”, IEEE International Conference on Automation Science and Engineering, pp. 1206-1211, 2014.
[11] Cameron Nicolson, "Risk mitigation associated with airport escalator and moving Sidewalk operations", Calgary airport authority, IAAE Canada accreditation candidate, Management Paper requirements of the International Association of Airport Executives Canada, 2008.
[12] Chen, J. S et al, "A multivariate regression model predicted falls in residents living in intermediate hostel care", Journal of Clinical Epidemiology, vol. 58, pp. 503–508, 2005.
[13] C. Harris and M. Stephens, "A combined corner and edge detector", in Alvey Vision Conference, pp. 147–152, 1988.
[14] C. Meng, "Analyses of safety hazard and solutions one escalator", Journal Equipment Manufacturing Technology, Vol. 18, No. 4, pp. 199-200, 2011.
[15] T. Raz and E. Michael, "Use and benefits of tools for project risk management", International Journal of Project Management, Vol. 19, No. 1, pp. 9-17, 2001.
[16] A. R. Green, "New techniques in assessment mine risk", In Proceedings of 26th International Conference of Safety in Mine Research Institute, pp. 113-117, 1995.
[17] Chonghui Song, Jingman Zhang, Yandong Wei, Chunyuan Bian, GeLi, "Group control of Escalators: Modelling Based on Data and Optimization of Distribution", 3rd International Conference on Intelligent Human-Machine Systems and Cybernetics, pp.197-200, 2011.
[18] Hopkins, R. S., "Consumer product-related injuries in Athens, Ohio, 1980–1985: assessment of emergency room-based surveillance”, American Journal of Preventive Medicine, Vol. 5, No. 2, pp. 104–112, 1989.
[19] G. Aggarwal, R. Motwani, and A. Zhu, “The Load Rebalancing Problem”, Journal of Algorithms, Vol. 60, No. 1, pp. 42–59, 2006.
[20] Davis, Y, Annest, J. L., Powell, K. E., Mercy, J. A., "An evaluation of National Electronic Injury Surveillance System for use in monitoring nonfatal firearm injury and obtaining national estimates", J. Safety Res, Vol.27,pp.83–91,1996.