# Fracture Analysis of Escalator Step and Comb Plate

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**Abstract**. The escalator step fractured during applications. The causes for the fracture of escalator step and comb plate were investigated by means of macroscopic fractography, optical microscope and scanning electron microscope. The analysis results indicate that some porosity defects with different size distributed in the escalator step support. The fracture mode of escalator step is overload fracture.

## 1. Introduction

In recent years, escalators are widely used in public places such as supermarkets, subway and shopping malls. With the increasing use of escalators, the property losses and casualties caused by escalator are rising year by year [1]. The safe operation of the escalator is getting more and more attention in the society [2, 3]. Escalator step is one of the most important parts of escalator and has been studied many researchers in the past years. From two aspects of equipment unsafe state and human unsafe behavior, Liang et al. [5] analyzed the reasons of an accident caused by the lack of escalator steps. Based on the results, preventive measures including two levels of risk prevention and technical regulations were put forward to avoid the happening of similar accidents. Based on the mechanical principle and design theories, an escalator step protection device is designed by Wang [4] with the help of SolidWorks and CAD to stop further injury after clamping on an escalator. It can reduce the injury degree effectively.

About ten steps of an escalator used in the shopping mall were arched upward and damaged due to the collision. In this investigation, the cause of escalator step fracture was analyzed using macro, scanning electron microscope and optical microscope.

## 2. Fracture Specimen and Analysis Method

The fractured escalator step and comb plate are shown in Fig. 1. The width and length of the escalator step are 400mm and 1000mm, respectively. It can be seen that the escalator step has obvious squeeze deformation and crack. The comb plates (No. 1-No. 5) have varying degrees of deformation and damage. The comb plate of No. 5 has serious fracture phenomenon. One part of the escalator step, which is corresponded to the No. 5 comb plate, has a defect.

Referring to JB/T 6842-1993 <Test methods of scanning electron microscope>, the fractures of escalator step were analyzed by the scanning electron microscope (SEM). Referring to GB/T 13298-2015 <Metal-inspection method of microstructure >, the microstructure of support draft hole was analyzed after etching by the mixed acid solution.


**Figure 1.** Escalator step and comb plate.

## 3. Results and Discussions

### *3.1. Macroscopic Fractography*

Macroscopic fractography of the escalator comb plate (No. 3#) is shown in Fig. 2. Ten combs have been fractured, which are related with the squeeze. The fracture surfaces are relatively rough and have the overload fracture characteristic. Local fracture surface has squeeze scratching phenomenon. Through further observation, two sides of the comb have unilateral wear phenomenon.

Macroscopic fractography of the escalator comb plate (No. 5#) is shown in Fig. 3. There are obvious bending deformation and comb broken phenomenon. The root zones of fractured comb plates have obvious squeeze and friction trace. It can be seen that the comb plate fracture surface has the bottom-up overload fracture characteristic. The two sides of comb plate also have the unilateral wear phenomenon.

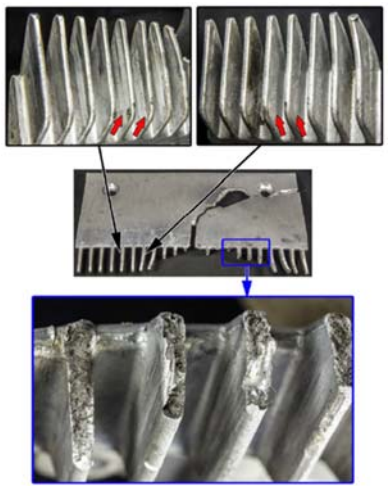

**Figure 2.** Macroscopic fractography of the escalator comb plate (No. 3#).

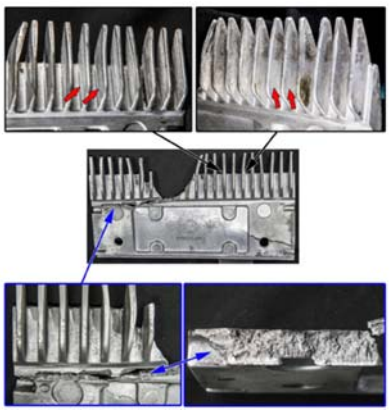

**Figure 3.** Macroscopic fractography of the escalator comb plate (No. 5#).

Macroscopic fractography of the escalator step support is shown in Fig. 4. It can be seen that both sides of step supports have fractured. The fracture surface is relatively rough. Owing to squeeze, the support close to the auxiliary wheel fractured and both sides were almost the same. On the upper side of the fracture, there was a herringbone pattern. Lots of pit defects can be seen on the fracture surface of both sides.

**Figure 4.** Macroscopic fractography of the escalator step support.

*3.2. SEM Analysis of Fracture*

The fractography of the fracture initiation region observed using scanning electron microscope under low magnification is shown in Fig. 5. It can be seen that some deeper pits distributed in local region. In the fracture initiation region, some flat regions with different size were found and the largest length is about 1.7mm. It can be inferred that the flat regions belong to cold lap defect.

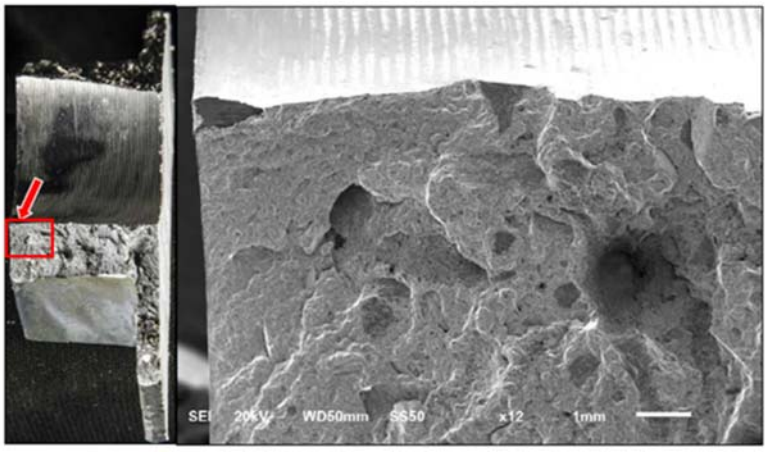


**Figure 5.** Fractography of the fracture initiation region.

The fractography of the fracture propagation region observed using scanning electron microscope under low magnification is shown in Fig. 6. Compared with the fracture initiation region, more porosity defects distributed in this region. The size of largest porosity defect is measured and the length and width of are about 5.5mm and 1.8mm, respectively.

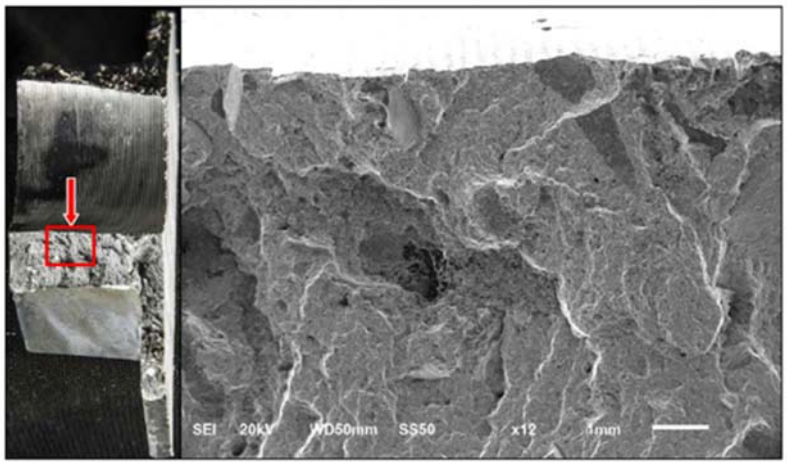


**Figure 6.** Fractography of the fracture propagation region.

The fractography of some porosity defects of the fracture initiation region under high magnification are shown in Fig. 7. It can be seen that the surface shows the free surface characteristic.

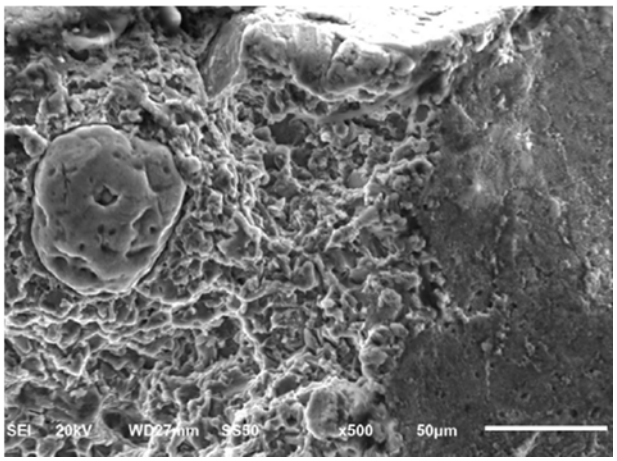


**Figure 7.** Fractography of the porosity defect of fracture initiation region.

*3.3. Microstructure Analysis*

The optical microstructure of the fracture region is shown in Fig. 8. It can be seen that the fracture surface is not very smooth and has no obvious plastic deformation. Lots of porosity defects distributed in the fracture initiation region. The matrixes of this region are α (Al) phase and eutectic silicon phase. The optical microstructure of the fracture propagation region is shown in Fig. 9. It also can be seen some different size porosity defects in fracture propagation region. The matrixes of this region are also α (Al) phase and eutectic silicon phase.

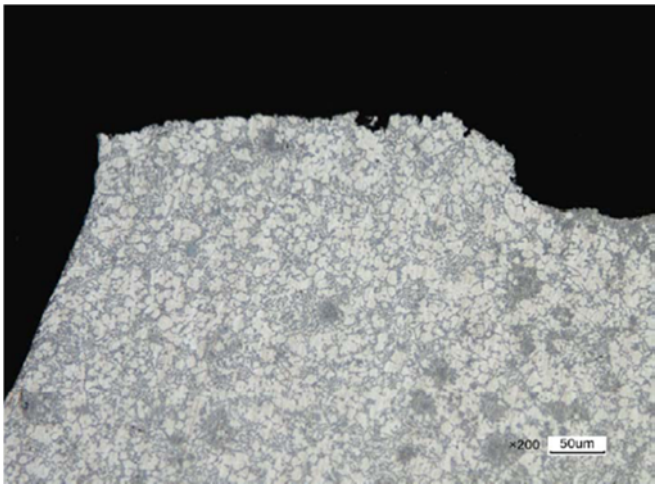


**Figure 8.** Optical microstructure of the fracture initiation region.

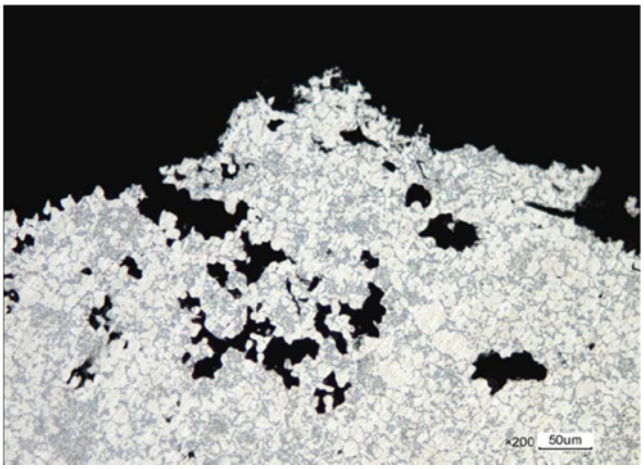


**Figure 9.** Optical microstructure of the fracture propagation region.

## 4. Conclusion

In this investigation, the causes for the fracture of escalator step and comb plate were investigated systematically. The escalator step supports have some porosity defects with different size, which can increases the probability of overload fracture under impact load. Based on the above analysis, the fracture mode of escalator step and comb plate is overload fracture.

## References

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