In the fourth case, the crossing had fallen into conflict state when the head of train was just about 450 meters away, so the train simply could not slow down to 15 km/h. However, it did not lead to a truly hazardous situation, because two of the barriers had reached the horizontal position, and all road signals were turned off.

b.) First 160 km/h variant

This variant was practically the same as the original, just the brake distances were lengthened to allow higher speed, and a new failure mode was introduced with 120 km/h speed restriction.

According to the expectations, the similar design resulted in similar test results, with slightly increased closing times (about 20%). Interestingly, trains moving above 120 km/h and braking with electromagnetic rail brake had stopped about halfway of the provided brake distance. This accurately meets the measured values from the real tests, and suggests that the brake distances may be a bit oversized for a typical passenger train.

c.) Second 160 km/h variant

Increasing track speed causes longer closing times for slower trains, which can be unfavorable for the road traffic. By deploying additional train detecting devices, closing time can be optimized for slower trains.

This variant has two pairs of axle counters for detecting the speed of the incoming train in two steps (below/above 120km/h). Because of these axle counter pairs detects only "high" speed trains, conventional track circuits were used for the "normal" speed trains. Since two additional balises are required for signalling the normal trains, not just the closing time but safety has been improved.

A very special situation was tested, when one of the road signals unexpectedly began to show free aspect, while a high speed train was between the normal and the high speed detecting devices. In this case, interestingly, due to the additional balises and the designed long brake distances, the test train could easily stop with emergency brake intervention before the crossing (Fig.8.)

d.) Third 160 km/h variant

Generally the same as the previous variant, but the railway signals are permissible, which makes the control subsystem much simpler. Another advantage is that when the level crossing is in conflict state, it is not necessary for the whole train to pass the crossing at reduced speed. As soon as the locomotive had left the crossing, the train could immediately accelerate.

4. CONCLUSION

However the described study could not utilize every powerful feature of the applied complex simulation system, it proved its efficiency and usefulness in the design process. Generally, all level crossing variants were working safe in the critical situations. It also had been proven that the suspected "safety hole" due to the non-continuous train controlling is not as serious as it looks for the first glance.

Important to note that the optimized variants with additional speed-sensitive train detecting devices are able to reduce the closing time up to 15 seconds for trains traveling at the high/normal switching speed (120 km/h). This means about 20% decrease in the waiting time for the road traffic, but with significant increase of costs.

REFERENCES

3. CALCULATION RESULTS AND GRAPHIC DEPENDENCIES

The numerical results in Table 1 have been found on the base of analytical dependency (7) for two typical values of $y_{\text{f}} = 1.8 \text{m} - \text{curve 1}$ and $y_{\text{f}} = 2.4 \text{m} - \text{curve 2}$ and the graphic dependencies of $E_z = f(x)$ have been built in Fig. 2.

Table 1.

<table>
<thead>
<tr>
<th>$E_z \text{ kV/m}$</th>
<th>Distance $x \text{ [m]}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1.6</td>
</tr>
<tr>
<td>2</td>
<td>1.3</td>
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<td>1.0</td>
</tr>
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<td>6</td>
<td>0.6</td>
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<tr>
<td>7</td>
<td>0.4</td>
</tr>
<tr>
<td>8</td>
<td>0.3</td>
</tr>
</tbody>
</table>

The problems of increasing the stability of radio and electronic equipment used in railway transport against the effect of electric and magnetic fields are part of the general theory of providing electromagnetic compatibility. In certain important aspects, which determine the operation of radio equipment under the conditions of railway transport [3], the distribution of contact network electric field strength has a specific character. In that sense, the obtained graphic dependencies and analytical expressions of assessment give a possibility to determine the distribution of the electric field as an essential component of electromagnetic compatibility. This distribution determines the quality and reliability of radio electronic equipment.

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4. CONCLUSIONS

The analytical dependencies worked out for contact network electric field potential and strength as well as the numerical results obtained give a possibility to look for providing the admissible effect of these interference. This effect should be in compliance with the existing standards in this field [4].

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