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Influence of Steel Reinforced Pavements on Aircraft System



Foto: VTI

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Preface

This report is a short version of the Swedish VTI notat 13-2004 “Stålarmering i flygfält – Kan stålnät i banor påverka flygplansinstrument?”. The study was conducted in cooperation between the Swedish National Road and Transport Research Institute (VTI), AerotechTelub, Linköping University (LiU) and the Geological Survey of Sweden (SGU). The LFV Group Swedish Airports and Air Navigation Services, the National Fortifications Administration and Fundia are acknowledged for their financial support.

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Abstract

This research investigated how steel nets used as reinforcement in taxiways and runways affect systems on board aircraft. It is stated that for High Intensity Radiated Fields from radio- or radar transmitters, steel nets have a smoothening effect and therefore decrease the risk of interference with aircraft systems. For aircraft compasses it is concluded that permanently magnetic steel nets constitute a significant source of interference. It was further concluded that steel nets, typically used as reinforcement, have such properties that they do not become permanently magnetic and consequently there is no risk of interference with aircraft compasses. Diverging compasses at Arlanda airport are explained as a consequence of using permanently magnetic steel nets of non-typical quality.

Possible impacts of steel nets on aircraft

The only system on board aircraft that rely on magnetic fields are the compasses. No other onboard system is influenced by magnetic fields and can consequently not be affected by any irregularity or disturbance in the earth's magnetic field. Aircraft are typically equipped with two compasses, one in each wing, and the system usually does not tolerate that any difference in indication between the two compasses of more than 5°. It can therefore not be tolerated that steel nets used to reinforce taxiways or runways change the direction of the horizontal component of the earth's magnetic field by more than a couple degrees at the height of installation of the compasses. These issues will be discussed in the following section.

So called High Intensity Radiated Fields (HIRF), from radio or radar transmitters, also constitute a potential risk of interference with aircraft equipment, in this case onboard electronic systems. For HIRF, steel nets have a smoothing effect and therefore decrease the risk of interference with aircraft systems.

Magnetic field at Arlanda Airport, Stockholm, Sweden

At Arlanda airport, Stockholm, deviating compasses have been frequently reported from aircraft taxiing to runway 01/19. Looking for the source of these disturbances, the magnetic field, over and at the side of the taxiway at a height of 2 m, was measured by the Geological Survey of Sweden (Schwarz, 1999). Figure 1 shows increased intensity at the centre and along the sides of the taxiway. In between these bands of increased intensity the magnetic field is weaker than the undisturbed earth's magnetic field. It was concluded that these anomalies are severe enough to explain the reported deviating aircraft compasses.

The section on numerical simulations below gives a possible explanation of the anomalies observed.

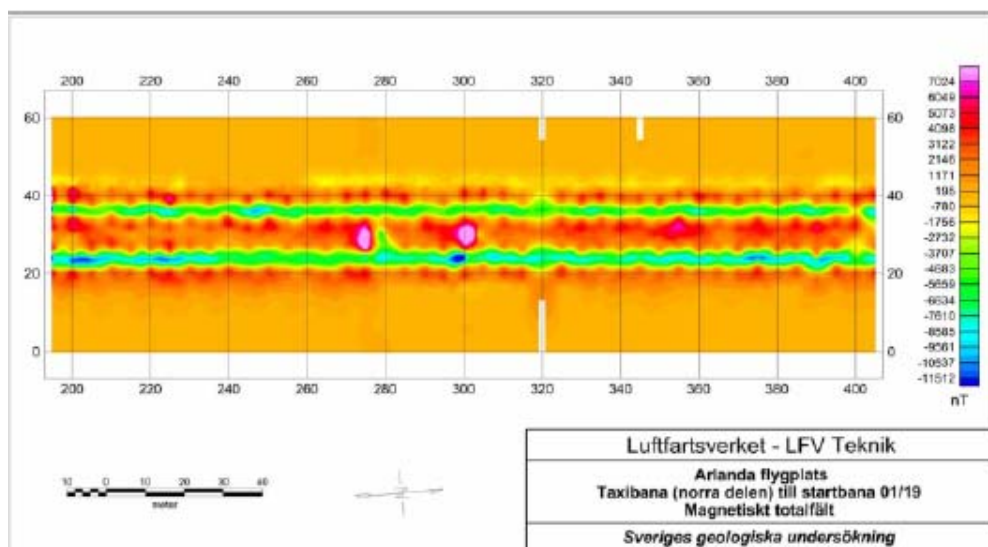


Figure 1 Magnetic field at a height of 2 m at Arlanda airport, over a length of 200 m of taxiway to runway 01/19. Red means high intensity while green and blue areas have lower intensity than the undisturbed earth's magnetic field.

Magnetic field around a steel net, experimental set-up, Linköping, Sweden

A 4 x 2 m steel net, typically used for reinforcement of cement concrete, was placed on horizontal ground and oriented with the long edge pointing to north. Measurements of the north and west components of the horizontal magnetic field were taken at a height of approximately 10 mm above the net. It was found, for example, that at the north edge of the net the earth's magnetic field was strongly disturbed. Moving the measuring probe 40 mm to the north could at some locations result in a change from -0.6 Gauss to 0.6 Gauss in the west component. This should be compared with a total horizontal intensity of 0.13 Gauss at undisturbed locations. Some of the locations showing high disturbance were marked out and checked after removing the net to ensure that nothing else but the net caused the disturbance of the earth's magnetic field.



Figure 2 Experimental set-up to study the effect of steel net on the earth's magnetic field.

It was concluded that at a height of 10 mm, the magnetic field was strongly affected by the steel net.

This was not the case though when measurements were taken at a height of approximately 200 mm above the net. The probe was tested at a great many different locations; above the net, above edges, close to edges above and outside the net. Not a single point at that height was found where the west or the north component seemed to be affected by the net. The instrument showed the same values as at undisturbed locations.

We concluded from this experiment that the steel net strongly affects the earth's magnetic field very close to the net but at a height of 2 m, above which the aircraft compasses are installed, there is no measurable disturbance caused by the net.

Numerical simulation of the impact of steel net on the earth's magnetic field

Extensive numerical simulations were performed by AerotechTelub, (Andersson, L. and Eriksson, G.,). The purpose of the simulation study was twofold – firstly to explain the anomalies observed at Arlanda Airport, and secondly to study how steel reinforcement in general affects the earth's magnetic field. In the study, the inclination of the magnetic field was set to 72° to simulate conditions at Arlanda Airport.

Although a high capacity PC was used for the study, it was not possible to model a steel net in full detail; some simplifications had to be made. Firstly, the meshes were modelled correctly but the net was set up as infinitely long and infinitely wide. From this model, it was concluded that at a height of 100 mm there are no significant disturbances.

Secondly, the net was modelled as a slab with such a thickness that the mass of the slab equals the mass of the net. This model was used to study how the magnetic field is affected above edges and above gaps between two nets. Different orientations of the edges in the horizontal plane were tested. It was found that none of the simulations performed resulted in disturbances of the magnitude observed at Arlanda Airport. To try to explain the Arlanda Airport anomalies, a permanently magnetic slab was modelled. Figure 3 shows how the magnetic field increases above a gap between two permanent magnetic slabs and that the magnetic field decreases above the slabs. Figure 4 shows the magnetic field at the edge of a permanent magnetic slab. The taxiway at Arlanda was reinforced with four sections of 6 m wide steel nets, resulting in gaps at coordinates 24, 30 and 36 in Figure 1. Assuming that the two inner sections are permanently magnetic, Figure 3 models the gap at coordinate 30, and assuming further that the outer nets are not permanently magnetic, Figure 4 models the edge of the permanently magnetic area. It was concluded that under these assumptions, the simulations explain the values taken at Arlanda Airport fairly well.

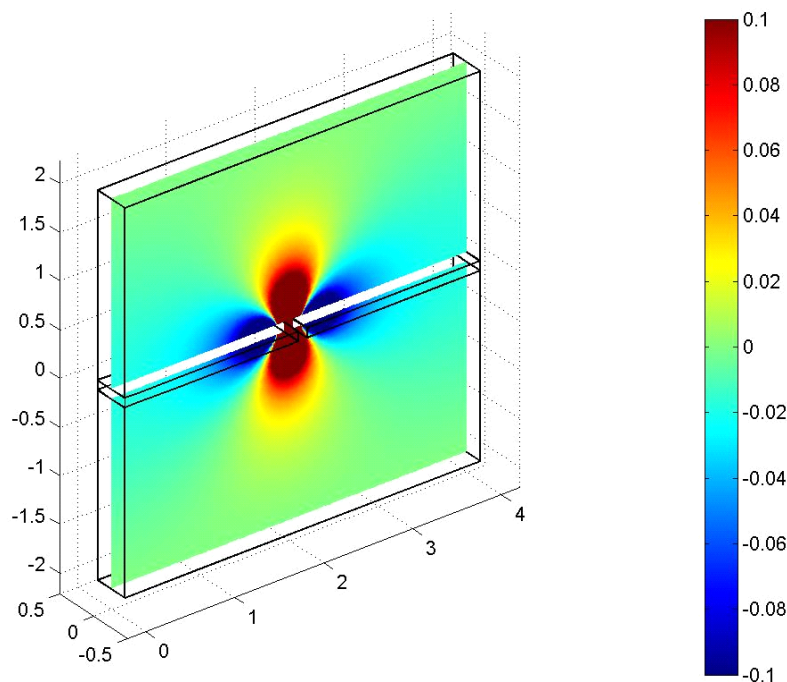


Figure 3 Calculated relative disturbance of the earth's magnetic field at a gap between two permanently magnetic slabs

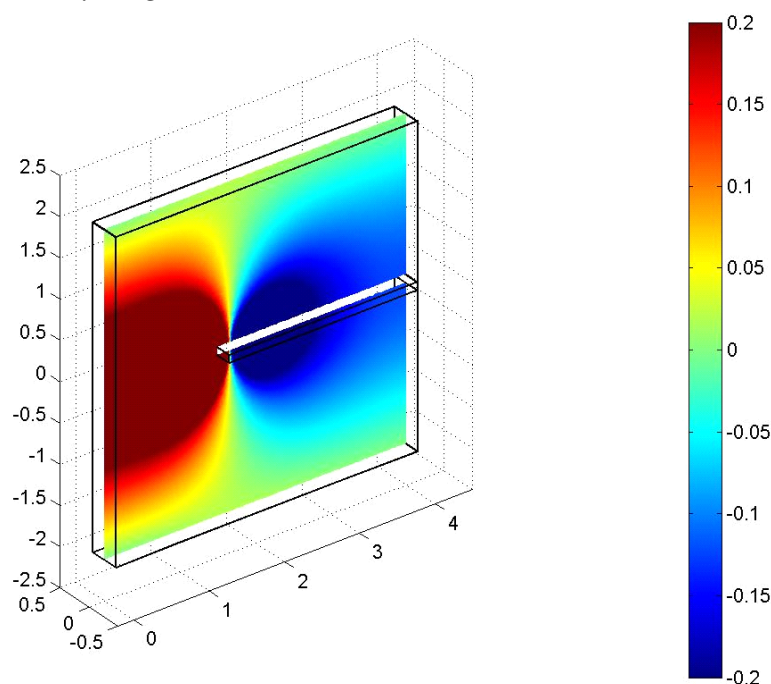


Figure 4 Calculated relative disturbance of the earth's magnetic field at edge of permanently magnetic slab.

From the simulations it was concluded that a steel net not being permanently magnetic does not significantly affect the earth's magnetic field at a height of 2 m above the net. Secondly, it was concluded that by modelling permanently magnetic nets it is possible to explain the anomalies observed at Arlanda Airport.

Discussion and conclusions

Today, the taxiway studied at Arlanda Airport has been rebuilt. During the excavation work, it was observed that the steel nets were hard to bend. When removing the crushed pieces of cement concrete, the nets acted like springs, which complicated loading onto trucks. This observation indicates that the nets were not of standard quality. Steel nets for reinforcement of cement concrete typically are very easy to bend permanently. Normally, it is very difficult to give such steel permanent magnetic properties. More spring-like steel, though, becomes permanently magnetic more easily.

This observation, together with the fact that a magnetic wagon had been used to collect waste over a 12 m wide area corresponding to the two inner net sections, led to the conclusion that permanent magnetic properties explain the anomalies observed at Arlanda Airport.

It was further concluded that using standard steel nets as reinforcement, that do not easily become permanently magnetic, there is no risk of interference with aircraft compasses.

References

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