GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

REPORT ON EFFECT OF VIBRATIONS DUE TO RAIL TRAFFIC ON STRUCTURES LOCATED ALONG RAILWAY TRACK

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CONTENT

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1. INTRODUCTION

Rail traffic generates vibrations mainly due to interaction between the wheels and the permanent way. These are mainly low frequency vibrations which propagates in all the directions in air as well as through ground surface and die out after certain distance. Train related vibrations propagate through the ground and produces vibrations in structures / buildings along side the track.

Due to operating requirements and availability of land , railway has to construct many structures such as cabins, level crossing gumties, station buildings and related structures close to track. Minimum horizontal distances for construction of building/ structures are given in Schedule of Dimensions (SOD). Fast urbanisation , in most of the cities, is also giving rise to construction of large number of non-railway buildings along the railway track . For such structures , vibrations generated due to moving rail traffic is perpetual sources of disturbance and can cause structural deterioration of structures . Proper care requires to be taken during design and construction of such structures.

2. OBJECTIVE

Study of effect of vibrations due to rail traffic on structures located along railway track and to suggest suitable strengthening measures if required.

3. METHODOLOGY

Indian Railway has vast net work of track on which goods as well as fast / super fasts , passenger trains move round the clock. As per Chapter II of Schedule of Dimensions minimum horizontal distance from center of track to any structure except the platform is 2135mm on BG track. However, minimum horizontal distance of any structure/ building on a passenger platform is 5182mm . Therefore, it was decided to measure both lateral as well as vertical vibrations at above mentioned distances under goods as well as passenger trains on main routes on Indian Railways i.e. Delhi-Mathura and Ghaziabad-Allahabad route. The measurements were also taken at two locations on Mumbai sub-urban section . The detailed test scheme for this study was prepared and placed as Annexure-I.

4. SELECTION OF SITES

The vibration measurement were taken on nine sites. Out of these, four sites were selected on railway platforms and remaining five were located on cess. Following sites were selected on above mentioned routes .

i) Km 1061/22-24 and Km 1061/11-13 near Rura Stn , Ghaziabad-Allahabad Section of Northern Railway. (Fig.-1)

ii) Km 1211/34 –1212/2 & Km 1211/15-17 near Shikohabad Stn , Ghaziabad-Allahabad Section of Northern Railway. (Fig.-2)

iii) Km 22/15-16 and Km 22/16-23/1 near Vikhroli, Mumbai – Kalyan suburban section of Central Railway. (Fig.-3)

iv) Km 1182/2-4, Km 1182/21-23 and Km 1183/1-3 near Dabra, Delhi-Jhansi section of Central Railway. (Fig.4)

5. FIELD MEASUREMENT OF VIBRATIONS

5.1 **Procedure** The vibration measurements were taken at the distance of 2134 & 5182 mm from centre of track. They were measured , recorded and analysed using lap top based data acquisition system . The accelerometers of 2.5 g were used for sensing the vibrations. Two nos. of accelerometers were clamped on heavy and stable L-shaped metal plate to measure acceleration amplitude in lateral and vertical directions. The steel plate was placed at level ground at desired distance from center of track. The vibration measurements were taken at locations 1 m above rail level to 3 m below rail level. Accelerometers clamped with metal plate is connected with lab top based data acquisition system. The accelerometers were calibrated by turning them at 90 degree and adjusting the voltage in lap top. Recording of vibrations started when train approached the site till it passed. Two no. of 12 v batteries were used to operate the accelerometer . Signal conditioner was used for amplification of electric signal. The analogue signals were change to digital signal through DAC Pad provided with lab top .The measurements were recorded under passing of through running passenger as well as goods train including super fast trains running in the section which includes Rajdhani Express / Shatabadi Expressd . Measurement were also taken in Mumbai suburban section . The acceleration records are placed at figure 5 to 44 .The field measurements were taken between June to September 2000.

5.2 **Train speed** Optical sensors were used for measuring the speed of running trains. The sensors works on the principle that when some object passes in front of the sensors a peak appears due to change in intensity of light. Two optical sensors were fastened to the bottom of rail at a distance of 25 m from each other and were connected to the laptop . The time was recorded during passing a wheel over the locations of these sensors to calculate speed of trains.

5.3 **Type of soil** Soil samples were collected from each site to determine type of soil . Classification tests were done at Geo Tech. Engg. Lab of RDSO. The results of these tests are placed at Table - 13 .The type of soils were clayey (medium as well as high plasticity), silty, and silty sand.

6. OBSERVATIONS

The maximum peak values of accelerations recorded under various train at different sites are shown in table I to 9. The RMS value of acceleration for each train is also shown along with the maximum peak values.

6.1 **Site No 1** (Rura Station) The details of accelerations observed on Rura Platform are placed as Table –1 Measurement were taken under Rajdhani and Gomti Express trains. The speed of trains varied from 104 to 125 kmph. The maximum peak & Root Mean Square (RMS) values of lateral acceleration at distances of 2134mm and 5182mm

6.2 from center of track were observed as 0.0264g , 0.0159g and 0.0591g , 0.0186g respectively. The maximum peak & RMS value of vertical acceleration at distances of 2134mm and 5182mm from center of track were observed as 0.0312g , 0.0139g and 0.0513g , 0.0285 g respectively.

6.2 **Site No 2** (Rura Station) The details of accelerations observed on cess are placed as Table –2 Measurement were taken under Super fast and Goods trains. The speed of trains varied from 104 to 69 kmph. The maximum peak and RMS values of lateral acceleration at distances of 2134mm and 5182mm from center of track were observed as 0.0327g, 0.0100g and 0.0302g, 0.0263g respectively. The maximum peak and RMS value of vertical acceleration at distances of 2134mm and 5182mm from center of track were observed as 0.0341g, 0.0041g and 0.0149g, 0.0078g respectively.

6.3 **Site No 3** (Shikohabad Station) The details of accelerations observed on Shikohabad Platform are placed at Table –3 Measurement were taken under Rajdhani , Super fast and Goods trains. The speed of trains varied from 140 to 66 kmph. The maximum peak and RMS values of lateral acceleration at distances of 2134mm and 5182mm from center of track were observed as 0.0151g, 0.0036g and 0.0171g, 0.0060g respectively. The maximum peak and RMS values of vertical acceleration at distances of 2134mm and 5182mm from center of track were observed as 0.0205g, 0.0060g and 0.0088g, 0.0050g respectively.

6.4 **Site No 4** (Shikohabad Station) The details of accelerations observed on cess are placed as Table –4. Measurement were taken under Rajdhani , Super fast and Goods trains. The speed of trains varied from 140 to 53 kmph. The maximum peak and RMS values of lateral acceleration at distances of 2134mm and 5182mm from center of track were observed as 0.0519g, 0.026g and 0.0264g, 0.021g respectively. The maximum peak and RMS values of vertical acceleration at distances of 2134mm and 5182mm from center of track were observed as 0.0337g, 0.007g and 0.0259g, 0.004g respectively.

6.5 **Site No 5** (Vikhroli Station, Mumbai suburban section) The details of accelerations observed on cess are placed as Table –5 Measurement were taken under Super fast and EMU trains. The speed of trains varied from 51 to 70 kmph. The maximum peak and RMS values of lateral acceleration at distances of 2134mm and 5182mm from center of track were observed as 0.0147g, 0.006g and 0.0054g, 0.0010g respectively. The maximum peak and RMS values of vertical acceleration at distances of 2134mm and 5182mm from center of track were observed as 0.0127g, 0.008g and 0.0015g, 0.001g respectively.

6.6 **Site No 6** (Vikhroli Station, Mumbai suburban section) The details of accelerations observed on platform are placed as Table –6. Measurement were taken under coupled loco and EMU trains. The speed of trains varied from 66 to 54 kmph. The maximum peak and RMS values of lateral acceleration at distances of 2134mm and 5182mm from center of track were observed as 0.0029g, 0.002g and 0.0034g, 0.002g respectively. The maximum peak and RMS values of vertical acceleration at distances of 2134mm and 5182mm from center of track were observed as 0.0073g, 0.004g and 0.0073g, 0.0060g respectively.

6.7 **Site No 7** (Dabra Station) The details of accelerations observed at on cess are placed as Table –7 . Measurement were taken under Shatabdi and Super fast trains . The speed of trains varied from 128 to 79 kmph. The maximum peak and RMS values of lateral acceleration at distances of 2134mm and 5182mm from center of track were observed as 0.0479g, 0.024g and 0.0122g, 0.0060g respectively. The maximum peak and RMS values of vertical acceleration at distances of 2134mm and 5182mm from center of track were observed as 0.0303g, 0.023g and 0.0137g, 0.0040g respectively.

6.8 **Site No 8** (Dabra Station) The details of accelerations observed on platform are placed as Table –8 Measurement were taken under Express and Goods trains . The speed of trains varied from 83 to 37 kmph. The maximum peak and RMS values of lateral acceleration at distances of 2134mm and 5182mm from center of track were observed as 0.0479g, 0.008g and 0.0122g, 0.0040g respectively. The maximum peak and RMS values of vertical acceleration at distances of 2134mm and 5182mm from center of track were observed as 0.0439g, 0.017g and 0.0137g, 0.0050g respectively.

6.9 **Site No. 9** (Dabra Station) The details of accelerations observed on cess are placed as Table –9 . Measurement were taken under Express and Goods trains . The speed of trains varied from 66 to 125 kmph. The maximum peak and RMS values of lateral acceleration at distances of 2134mm and 5182mm from center of track were observed as 0.0337g, 0.008g and 0.0156g, 0.0070g respectively. The maximum peak and RMS values of vertical acceleration at distances of 2134mm and 5182mm from center of track were observed as 0.0508g, 0.013g and 0.0186g, 0.0080g respectively.

The maximum peak and RMS values of accelerations on platform and cess are shown in table No. 10.& 11

7.0 STUDY BY ORE

Office of Research and Experiments of International Union of Railways (ORE) has also carried out a study on ground vibrations due to railways and has issued report no.D151 / RP 12 in April 1989 in reference to question D151. The report has included study of ground vibrations due to railways including effect of vibrations on people and buildings. It was concluded that vibration levels generated by railways are of low magnitude and it is most unlikely that building will suffer structural damage due to them.

8.0 DISCUSSION OF RESULTS

8.1 The maximum peak and RMS value of lateral acceleration at a distance of 2134mm on platform were observed as 0.0479g and 0.0080g under goods train on Jhansi-New Delhi section. The maximum peak and RMS value of vertical acceleration were observed as 0.0312g and 0.014g on Ghaziabad-Allahabad Section under Express train. The maximum peak and RMS values of lateral and vertical acceleration on platform at a distance of 5182 mm from center of track were observed as 0.0591g and 0.019g and 0.0513g, 0.029g respectively on Ghaziabad-Allahabad Section under Express trains.

8.2 The maximum peak and RMS value of lateral acceleration on cess at a distance of 2134 mm from center of track was observed as 0.0519g & 0.014g on Ghaziabad-Allahabad Section under goods train. The maximum peak and RMS values of vertical acceleration at the same location were observed 0.0508g & 0.0090g on Jhansi - New

Delhi Section under Express train.. The maximum peak and RMS values of lateral acceleration on cess at a distance of 5182 mm were observed as 0.0270g & 0.0260g on Ghaziabad-Allahabad Section under Express train.. The maximum peak & RMS values of vertical acceleration at the same location were observed as 0.0186g & 0.0040g on Jhansi-New Delhi Section under Express Train.

8.3 The maximum peak values of accelerations observed at 2134mm from center of track for all the runs recorded at all the locations varies from 0.0029g to 0.0519g as shown in table 12 ,. However , these peak values are very short duration of the order of fraction of a second and will not have much effect on structures. The peak value may occur due to various reasons such as wheel defect or irregularities in track etc. Therefore, RMS value of acceleration was also determined to assess general level of accelerations during passing of trains. The mean of RMS values of lateral and vertical accelerations for all the runs observed on all the sites varies from 0.001g to 0.022g and 0.001g to 0.0181g respectively The accelerations amplitudes observed at 2134mm and 5182mm from center of track are almost of the same level. This may happen as the vibrations are of low frequency (2 to 6 Hz) which might not died while propagating this distance through the ground.

8.4 No fixed relationship has been observed between lateral and vertical accelerations at the same locations. Mostly lateral accelerations are higher than vertical accelerations but in some cases vertical accelerations were also found higher than lateral accelerations at the same locations. The accelerations observed under EMU trains on Mumbai CST – Kalyan Sub-urban Sections are much lower than observed at other sites.

8.5 The maximum peak and RMS values of accelerations observed on platform and cess are shown in Table 10. Almost same amplitude of vibrations were observed on platform and cess.

8.6 Strengthening measures for design and construction of buildings based on lateral vibrations is given in IS 4326 : *1993 (Earthquake resistant design and construction of building – Code of practice)* The vibrations due to earthquake were considered for this purpose and the buildings requiring strengthening measures have been categorised in five categories based on the value of design seismic coefficient (α_h) as reproduced below:-

Building categories	Range of α_h
A	0.04 to less than 0.05
B	0.05 to 0.06 (both inclusive)
C	More than 0.06 and less than 0.08
D	0.08 to less than 0.12
E	Equal to or more than 0.12

$\alpha_h = \alpha_0 \times I \times \beta$

Where

α_h = Design seismic coefficient for the building.

α_0 = Basic seismic coefficient for the seismic zone in which the building is located.

I = Importance factor applicable to the building

β = Soil foundation factor

In case, the value of α_h is less than 0.04 , no strengthening measures are required for any type of buildings.

8.7 To obtain the value of α_h , the values of α_0 , I , and β are given in Table 2, Table-4 and Table-3 respectively of IS-1893 : 1984 (*Criteria for earthquake resistant design of structures*) and are reproduced below:

Values of Importance Factor (I)

S.N.	Structure	Importance Factor (I)
1	Dams (all types)	3.0
2	Containers of inflammable or poisonous gases or liquids	2.0
3	Important service and community structures, such as hospitals, water towers and tanks, schools, important bridges, important power houses, monumental structures, emergency buildings like telephone exchange and fire bridge, large assemblies structures like cinemas, assembly halls and sub ways sections.	1.5
4	All others.	1.0

8.8 Values of Soil Foundation Factor β for different soil foundation systems

S N	Type of soil mainly constituting the foundation	Values of β				
		Piles passing through any soil but resting on soil type I	Piles not covered under column III	Raft founda -tions	Combined or isolated RCC footings with tie beams	Isolated RCC footings without tie beams or unrein-forced strip foundations.
I	II	III	IV	V	VI	VII
1	Type I rock or hard soils	1.0	--	1.0	1.0	1.0
2	Type II medium soils	1.0	1.0	1.0	1.0	1.2
3.	Soft soils	1.0	1.2	1.0	1.2	1.5

8.9 The vibrations generated due to rail traffic along railway track were used instead of those generated due to earthquake to determine strengthening measures to cater for these vibrations. The value of observed lateral acceleration due to rail traffic was considered as basic seismic coefficient (α_0) for computing α_h (Design seismic coefficient for the building). The maximum peak RMS value of lateral acceleration 0.026g observed on all the sites was used to compute α_h .

8.10 Design seismic coefficient for three worst combinations considering soil foundation system and important building factor are given below:-

S. N.	Combination	Important factor for Building (I)	Soil foundation Factor (β)	Design seismic coe - fficient α_h	Strengthening measures
1	Normal buildings on medium soils	1.0	1.5	0.039	No strengthening measure is required for any type of building as the α_h is less than 0.04
2	Important service and community structures founded on medium soils	1.5	1.2	0.047	No special strengthen- ing measure other than use of 1:6 cement mortar or 1:3 lime mortar or richer to withstand this level of vibrations.
3	Important service and community structures founded on soft soils with isolated footings.	1.5	1.5	0.059	In this case building needs strengthening measures as indicated in IS -4326.

8.11 Normally buildings located along railway track falls under combinations 1 & 2 , for which no strengthening measures are required. Further, the peak RMS value of lateral accelerations i.e.0.026 g is considered to work out design seismic coefficient α_h which is highest value observed over all the sites. The value of α_h is less than 0.04 for lateral acceleration of 0.017g or less for which no strengthening measures are required for any type of buildings on any type of soil. Out of total observed values of lateral accelerations only 86 % values are less or equal to 0.017g.

8.12 For combination 3 , the soil foundation factor 1.5 has been recommended only in case for isolated RCC footings without tie beams or unreinforced strip foundation located on soft soil. The importance factor 1.5 is recommended for important service and community structures such as hospital , schools, water towers and tanks, important power houses, monumental structures , emergency buildings like telephone exchange and fire bridge, large assembly structures like cinemas, assembly halls and sub way stations. Such type of structures are not located at a distance of 5182mm from centre of track where the measurements were taken. Therefore, *this condition is a rare case* and it is not desirable to consider this condition for buildings located along railway track.

9.0 CONCLUSION

In view of the above discussions and observations taken on various locations on cess as well as platform, it is concluded that no special strengthening measures are required for buildings located along railway track to withstand the effect of vibrations generated due to rail traffic.

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TEST SCHEME

EFFECT OF VIBRATIONS ON BUILDINGS/ STRUCTURES ALONG THE RAILWAY TRACK

1. Introduction

Running trains cause vibrations to structures located along the Railway tracks. Due to fast urbanisation, more and more buildings are being constructed along the tracks. As a result, there is growing concern over the effect of vibrations to buildings. Commissioner of Railway Safety conducted a statutory enquiry for collapse of RMS building on Platform no. 6 of Dadar Railway Station on 21.10.97. Vide item 9.4(I) of enquiry, CRS had recommended as below:

" Railway Board to direct RDSO, Lucknow to take up studies on the effect of Vibration on structures located along the Railway Track and arrive at suitable provision in IRS Codes for design of such structures".

Consequently , Board directed RDSO to conduct study as recommended above vide Director, LM's letter no. 97/LM(B)/3/34 dt. 3.6.98.

2. Objective

To record vertical & lateral vibrations along the track under rail traffic at different locations , compare them with provisions available in IRS/BIS codes and to suggest suitable provision in IRS Codes for design of structures if required.

3. Location of measurement

Accelerations of vibrations shall be recorded at different distances and depths from the centre of the track and Rail level respectively as per sketch-I . Recording will be done at four different sites both under goods & passenger trains preferably on Delhi-Mathura and Ghaziabad-Allahabad Route.

4. Observations

Vibrations will be recorded at each site under minimum three goods trains and three mail/express trains . Recording will be done at prevailing speeds of passenger and goods trains. The speed of the train will be measured by fixing strain gauges on the web of rail. Out of four sites , sites will be selected of different types of soil.

5. Equipments

i) Accelerometer 2.5g : To sense the vibrations
ii) Signal conditioner: For amplification of electrical signals.
iii) DAC Pad : To change analogue signals to digital signals.

iv) Computer: For Recording, storage, display & analysis of data.
v) Iron plate: Heavy L shaped Iron Plate to fix accelerometer at selected location.
vi) Strain gauge and chart recorder : for measurement of speed of the train
vii) DG Set for power supply to various equipments
viii) Battery: Two numbers of 12 V batteries are required to power up accelerometer and amplifier.

6. **Procedure:**

About 60cmx60cm area will be cleaned and levelled at selected locations for placing L shape steel plate . One no. of accelerometer will be fixed in vertical direction and one no. in horizontal direction on L shape plate. Necessary connection will be made from accelerometer to laptop computer through DAC pad. Both the accelerometer will be calibrated by turning L shape plate to 90 degree and correlating the acceleration signal to voltage. The vibration will be recorded during passing the trains at that locations. The velocity of passing trains will be measured by fixing 40mm strain gauges on web of the rail and connecting the same to amplifier and strip chart recorder. Circuit diagram for instrumentation is shown in sketch-II.

7. Any changes/deviations from above test scheme shall be got approved from ED/B&S.

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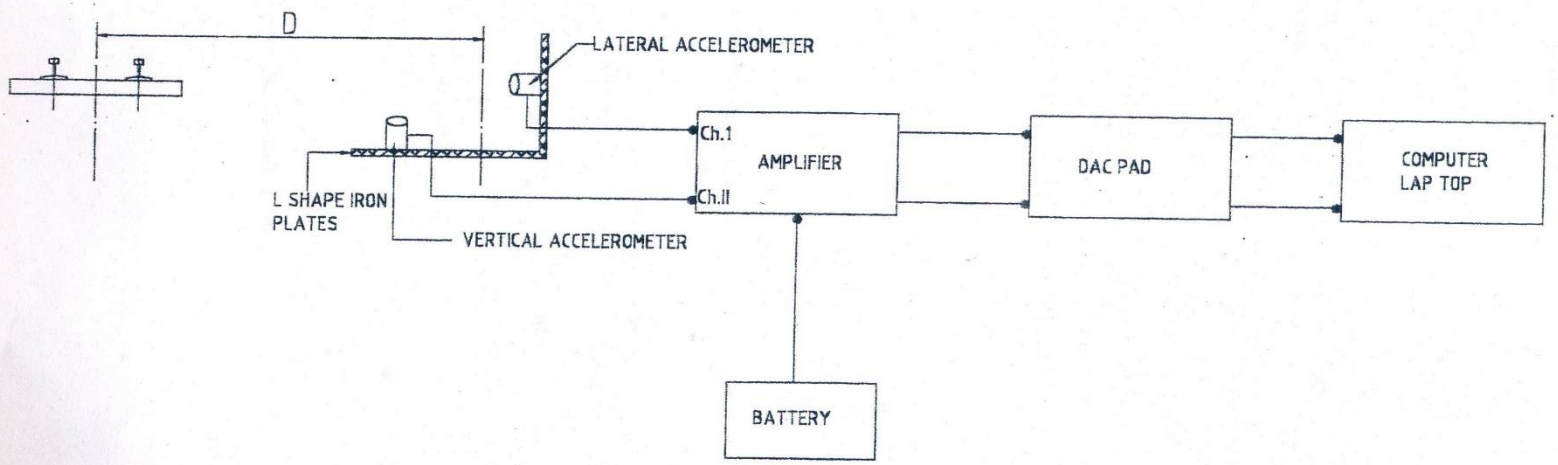
INSTRUMENTATION DIAGRAM FOR RECORDING VIBRATIONS



Lateral & Vertical Acceleration due to Rail Traffic

(Site No. 1)

Section: Ghaziabad-Allahabad
Location – Km 1061/22-24, Dn-Line (Rura Station)
Date of trials: 9th June & 8th Aug 2000

S. No	Train No.	Speed in Kmph	Acceleration as a part of 'g'							
			At a distance 2134 mm from centre of track.				At a distance 5182 mm from centre of track.			
			Lateral		Vertical		Lateral		Vertical	
			Peak	RMS	Peak	RMS	Peak	RMS	Peak	RMS
1	2424 Rajdhani Express	125.0	0.0264	0.0122	0.0298	0.0154	0.0117	0.0138	0.0332	0.0060
2	2420 Gomti Express	125.0	0.0254	0.008	0.0210	0.0133	0.0098	0.0285	0.0513	0.0063
3	2420 Gomti Express	104.0	0.0145	0.0139	0.0312	0.0058	0.0591	0.0171	0.0174	0.0186

Measurements were taken on platform (550 mm high above rail level).

(Site No. 2)

Section: Ghaziabad- Allahabad
Location – Km 1061/11-13, Dn-Line (near Rura cabin)
Date of trials: 10th June 2000

S. No.	Train No.	Speed in Kmph	Acceleration as a part of 'g'							
			At a distance 2134 mm from centre of track.				At a distance 5182 mm from centre of track.			
			Lateral		Vertical		Lateral		Vertical	
			Peak	RMS	Peak	RMS	Peak	RMS	Peak	RMS
1	4055 Brahmaputra Mail	70.0	0.0178	0.0038	0.0288	0.0088	0.0302	0.0078	0.0115	0.0263
2	2417 Prayag Raj Express	104.0	0.0171	0.0035	0.0173	0.0100	0.0221	0.0049	0.0093	0.0273
3	2553 Vaishali Express	70.0	0.0327	0.0041	0.0341	0.0042	0.0270	0.0040	0.0149	
4.	Goods Train ,DDL	72.0	0.0284	0.0027	0.0206	0.0024	0.0270	0.0241	0.0089	0.0082

Measurements were taken on cess (760 mm below rail level.)

Lateral & Vertical Acceleration due to Rail Traffic

(Site No. 3)

Section: Ghaziabad- Allahabad
Location – Km 1211/34-1212/2, Dn-Line (Shikohabad Station)
Date of trials: 9th & 10th Aug. 2000

S. No	Train No.	Speed in Kmph	Acceleration as a part of 'g'							
			At a distance 2134 mm from centre of track.				At a distance 5182 mm from centre of track.			
			Lateral		Vertical		Lateral		Vertical	
			Peak	RMS	Peak	RMS	Peak	RMS		
1	2802 Pushottam Exp.	102.0	0.0112	0.001	0.0103	0.001	0.0068	0.002	0.0064	0.022
2	2418 Pryagraj Express	112.5	0.0107	0.002	0.0068	0.013	0.0049	0.015	0.0049	0.006
3	2314 Rajdhani Express	140.6	0.0132	0.003	0.0156	0.003	0.0171	0.012	0.0083	0.003
4	5708 Baruni Express	86.5	0.0059	0.023	0.0205	0.036	0.0064	0.029	0.0088	0.004
5	Goods Train	66.2	0.0151	0.022	0.0171	0.033	0.0064	0.022	0.0028	0.006

Measurements were taken on platform (745 mm below rail level.)

(Site No.4)

Section: Ghaziabad - Allahabad
Location – Km 1211/15-17, UP-Line (near Shikohabad cabin)
Date of trials: 10th Aug. 2000

S. No	Train No.	Speed in Kmph	Acceleration as a part of 'g'							
			At a distance 2134 mm from centre of track.				At a distance 5182 mm from centre of track.			
			Lateral		Vertical		Lateral		Vertical	
			PEAK	RMS	PEAK	RMS	PEAK	RMS	PEAK	RMS
1	2421 Rajdhani Exp	140.6	0.0161	0.007	0.0064	0.029	0.0244	0.003	0.0259	0.003
2	Goods Train	53.3	0.0313	0.003	0.0239	0.026	0.0151	0.003	0.0088	0.015
3	Goods Train	70.3	0.0519	0.003	0.0337	0.014	0.0264	0.002	0.0181	0.021
4	2419 Gomti Express	102.3	0.0386	0.001	0.0327	0.018	0.0132	0.004	0.0083	0.023

Measurements were taken on cess (660 mm below rail level.)

Lateral & Vertical Acceleration due to Rail Traffic

(Site No. 5)

Section: Mumbai CST- Kalyan.
Location – Km 22/16-23/1, Dn-Line, (near Vikroli cabin)
Date of trials: 26th Aug. 2000

S. No.	Train No.	Speed in Kmph	Acceleration as a part of 'g'							
			At a distance 2134 mm from centre of track.				At a distance 5182 mm from centre of track.			
			Lateral		Vertical		Lateral		Vertical	
			Peak	RMS	Peak	RMS	Peak	RMS	Peak	RMS
1	374 EMU	70.0	0.0147	0.007	0.0127	0.006	-		-	
2	491EMU	53.0	0.0098	0.008	0.0093	0.004	-		-	
3	301 EMU	51.3	-		-		0.0044	0.027	0.0010	0.011
4	2619 Matsyagandha Exp	56.3	-		-		0.0054	0.018	0.0015	0.016
5	1439 Sewagram Exp	65.3	-		-		0.0049	0.033	0.00015	0.001

Measurements were taken on cess (470 mm mm below rail level.)

Note: Due to defect in accelerometer both reading could not be taken at a time.

(Site No. 6)

Section: Mumbai CST- Kalyan.
Location – Km 22/15-16, UP-Line, (Vikhroli Station)
Date of trials: 23rd - 28th Aug. 2000

S. No.	Train No.	Speed in Kmph	Acceleration as a part of 'g'							
			At a distance 2134 mm from centre of track.				At a distance 5182 mm from centre of track.			
			Lateral		Vertical		Lateral		Vertical	
			Peak	RMS	Peak	RMS	Peak	RMS	Peak	RMS
1	Coupled Locos	66.1	0.0010	0.003	0.0054	0.003	-		-	
2	336 EMU/310 EMU	62.5	0.0010	0.005	0.0054	0.002	0.0034	0.006	0.0073	0.002
3	485 EMU	56.6	0.0020	0.004	0.0044	0.002	-		-	
4	514 EMU	66.2	0.0024	0.005	0.0054	0.001				
5	448 EMU/508 EMU	62.5	0.0009	0.004	0.0073	0.001	0.0020	0.0004	0.0059	0.0003
6	184 EMU	53.8	0.0020	0.004	0.0063	0.001	-		-	
7	144 EMU	53.8	0.0029	0.008	0.0063	0.002	-		-	

Measurement were taken on platform (835 mm above the rail level.)

Note: Due to defect in accelerometer both reading could not be taken at a time.

Lateral & Vertical Acceleration due to Rail Traffic

(Site No.7)

Section: Jhansi-New Delhi
Location – Km 1182/2 - 4, Dn-Line (near Dabra cabin)
Date of trials: 12th Sept. 2000

S. No.	Train No.	Speed in Kmph	Acceleration as a part of 'g'							
			At a distance 2134 mm from centre of track.				At a distance 5182 mm from centre of track.			
			Lateral		Vertical		Lateral		Vertical	
			Peak	RMS	Peak	RMS	Peak	RMS	Peak	RMS
1	2137 Punjab Mail	79.6	0.0479	0.035	0.0166	0.004	0.0122	0.004	0.0137	0.005
2	2001 Shatabdi Express	128.0	0.0288	0.023	0.0303	0.020	0.0103	0.004	0.0083	0.016

Measurement were taken on cess (670/1070 mm below rail level.)

(Site No. 8)

Section: Jhansi-New Delhi
Location – Km 1182/21-23, UP-Line (Dabra Station),
Date of trials: 14th Sept. 2000

S.No.	Train No.	Speed in Kmph	Acceleration as a part of 'g'							
			At a distance 2134 mm from centre of track.				At a distance 5182 mm from centre of track.			
			Lateral		Vertical		Lateral		Vertical	
			Peak	RMS	Peak	RMS	Peak	RMS	Peak	RMS
1	2626 Kerala Exp	80.4	0.0176	0.017	0.0259	0.025	0.0088	0.005	0.0010	0.001
2	Goods Train	83.0	0.0479	0.008	0.0166	0.008	0.0122	0.004	0.0137	0.015
3	Goods Train	37.5	0.0132	0.006	0.0244	0.007	-		-	
4	Goods Train	56.0	0.0112	0.011	0.0439	0.028	-		-	

Measurement were taken on platform (420 mm above rail level.)
Note: Due to defect in accelerometer both reading could not be taken at a time.

(Site No.9)

Section: Jhansi-New Delhi
Location – Km 1183/1-3, Dn-Line (near Dabra cabin),
Date of trials: 13th Sept. 2000

S.No.	Train No.	Speed in Kmph	Acceleration as a part of 'g'							
			At a distance 2134 mm from centre of track.				At a distance 5182 mm from centre of track.			
			Lateral		Vertical		Lateral		Vertical	
			Peak	RMS	Peak	RMS	Peak	RMS	Peak	RMS
1	2408 MahamayaExp.	125.0	0.0166	0.009	0.0508	0.008	0.0156	0.004	0.0112	0.005
3	Goods Train	66.2	0.0115	0.013	0.0151	0.006	0.0103	0.008	0.0122	0.004
3	2618 Mangla Exp.	102.3	0.0337	0.002	0.0127	0.006	0.0132	0.004	0.0186	0.007

Measurement were taken on cess (450mm below rail level.)

****

Table No.10

Maximum peak & RMS values of acceleration observed on Platform

S.N	Section	Location in Km	Acceleration at 2134 mm distance				Acceleration at 5182 mm distance			
			Lateral		Vertical		Lateral		Vertical	
			Peak	RMS	Peak	RMS	Peak	RMS	Peak	RMS
1	GZB-ALD	1061/22-24 (Rura Platform)	0.0264	0.015	0.0312	0.014	0.0591	0.019	0.0513	0.029
2.	GZB-ALD	1211/34-1212/2 (Shikohabad Platform)	0.0151	0.002	0.0205	0.006	0.0054	0.003	0.0088	0.004
3.	MCST-Kalyan	22/16-23/1 (Vikroli Platform)	0.0029	0.002	0.0303	0.004	0.0034	0.002	0.0073	0.006
4.	JHS-NDLS	1182 / 2-4 (Dabra Platform)	0.0479	0.008	0.0259	0.017	0.0122	0.002	0.0137	0.004
MEAN			0.0321	0.0070	0.0270	0.0100	0.0200	0.0060	0.0203	0.0110

Table No.11

Maximum peak & RMS values of acceleration observed on cess

SN	Section	Location	Acceleration at 2134 mm distance (g)				Acceleration at 5182 mm distance (g)				Soil type
			Lateral		Vertical		Lateral		Vertical		
			Peak	RMS	Peak	RMS	Peak	RMS	Peak	RMS	
1	GZB-ALD	Km. 1061/11-13	0.0288	0.004	0.0331	0.004	0.0267	0.026	0.0187	0.004	Med. Clay
2	GZB-ALD	Km. 1211/15-17	0.0519	0.0.014	0.0337	0.003	0.0264	0.021	0.0181	0.003	Silt
3	CST-Kalayan	Km. 22/16-23/1	0.0147	0.006	0.0127	0.007	0.0054	0.001	0.0015	000	Silty sand
4	JHS-NDLS	Km. 1182/2-4	0.0479	0.024	0.0303	0.023	0.0122	0.006	0.0137	0.004	Silt (High plasti city)
5	JHS-NDLS	Km. 1183/1-3Express	0.0337	0.006	0.0508	0.009	0.0156	0.005	0.0186	0.004	Silt (High plasti city)

Table No.12

Maximum peak, mean of peaks & RMS values of accelerations

Site No.	Acceleration at 2134mm from center of track (g)						Acceleration at 5182mm from center of track (g)					
	Lateral			Vertical			Lateral			Vertical		
	Max Peak	Mean of max. peak	Mean RMS	Max Peak	Mean of max Peak	Mean RMS	Max Peak	Mean of max peak	Mean RMS	Max Peak	Mean max. peak	Mean RMS
1	0.0264	0.0221	0.0115	0.0312	0.0273	0.0114	0.0591	0.0269	0.0103	0.0513	0.0340	0.0181
2	0.0288	0.0240	0.0064	0.0331	0.0252	0.0035	0.0267	0.0218	0.0159	0.0187	0.0112	0.0052
3	0.0151	0.0112	0.0025	0.0205	0.0141	0.0030	0.0171	0.0083	0.0030	0.0088	0.0062	0.0030
4	0.0519	0.0345	0.015	0.0337	0.0242	0.0040	0.0264	0.0148	0.0090	0.0259	0.0153	0.0030
5	0.0147	0.0123	0.0050.	0.0127	0.0110	0.0080	0.0054	0.0049	0.0010	0.0015	0.0013	0.0000
6	0.0029	0.0017	0.0001	0.0073	0.0058	0.0030	0.0034	0.0027	0.0012	0.0073	0.0066	0.0032
7	0.0479	0.0384	0.022	0.030-3	0.0235	0.0014	0.0122	0.0113	0.0040	0.0137	0.0110	0.0040
8	0.0479	0.0225	0.0070	0.0439	0.0277	0.0110	0.0122	0.0105	0.0015	0.0137	0.0074	0.0020
9	0.0337	0.0206	0.0070	0.0508	0.0262	0.0080	0.0156	0.0130	0.0050	0.0186	0.0140	0.0050

FORMAT NO:- GTF/0C

Government of India-Ministry of Railways
RDSO, Lucknow-226011
GEOTECHNICAL ENGINEERING LABORATORY

NAME OF PROJECT : Rura-Kanpur Tundla Sec. Allahabad Div N.Rly.

REFERENCE.No.: 96/2000 dt. 28.11.2000

Laborntory Sample no. 2000 BRS	Location (Km/Ch)	Depth of Sample (m)	Soil Classification as per IS Specification	Natural Moisture Content (NMC)	Natural Dry Density (NDD) g/cc %	MECHANICAL ANALYSIS				Passing 75 Micron Sieve %	CONSISTENCY LIMIT				Differential Swelling	Optimum Mosture Content (OMC) %	Max. Dry Density (MDD) g/cc	DIRECT/TRIAXIAL SHEAR TEST UNDER UNDRAINED/ DRAINED		REMAR
						Gravel %	Sand %	Silt %	Clay %		Liquid Limit %	Plastic Limit %	Plasticity Index %	Shrinkage Limit %				Cohesion kg/cm²	Angle of internal friction ϕ	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0464			CI			1	13	79	7	86	37	20	17							

17

P.O. WAY NO.- GTE/0018

RDSO, Lucknow-226011

GEOTECHNICAL ENGINEERING LABORATORY

NAME OF PROJECT : TESTING OF SOIL SAMPLES

REFERENCE.No.: CBS/EVS/dt 4.10.2000
Report NO. 83/2000

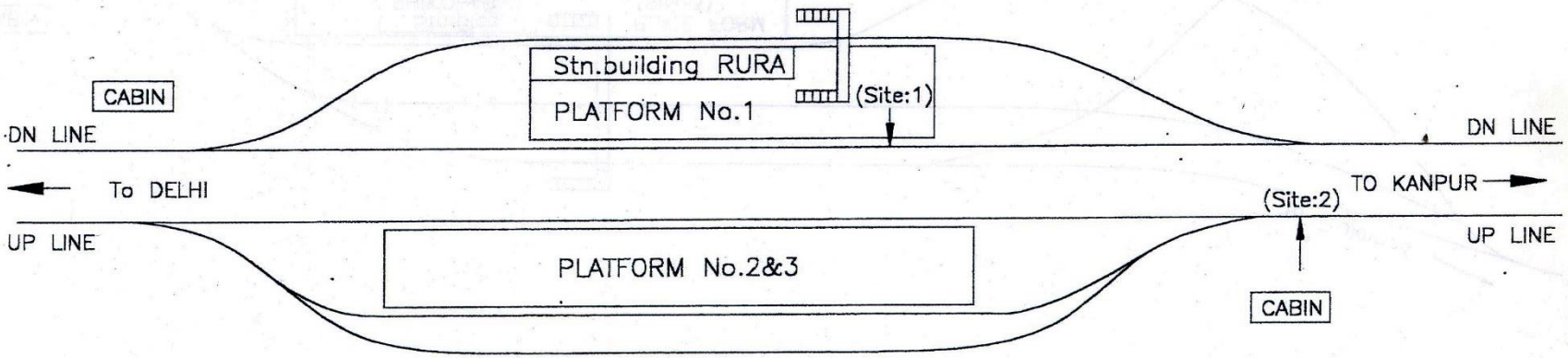
Laboratory Sample no.	Location (Km/Ch)	~~Depth of~~ Sample (m) Field Sample No-	Soil Classification as per IS Specification	Natural Moisture Content (NMC)	Natural Dry Density (NDD) g/cc %	MECHANICAL ANALYSIS				Passing 75 Micron Sieve %	CONSISTENCY LIMIT				Differential Swelling	Optimum Moisture Content (OMC) %	Max. Dry Density (MDD) g/cc	DIRECT/TRIAXIAL SHEAR TEST UNDER UNDRAINED/ DRAINED		REMARKS
						Gravel %	Sand %	Silt %	Clay %		Liquid Limit %	Plastic Limit %	Plasticity Index %	Shrinkage Limit %				Cohesion kg/cm²	Angle of internal friction ϕ	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
2000/BES						~~03~~														
0422	Etawah CBS/EVS/1 Tundla Km-121/15-17		ML			03	34	60	03	63	NP	NP	NP							
0423	Mumbai CBS/EVS/2 CST-Kalyan Km-22/16-23/2		SM			10	53	34	03	37	NP	NP	NP							
0424	Jhansi CBS/EVS/3 Gwalior Km-1182/2-4		MH			Nil	23	69	08	77	61	50	11							
0425	~~Gwalior~~ Jhansi CBS/EVS/4 Km 1183/1-3		MH			Nil	09	71	20	91	75	54	21							

CRA/42 dt 6/11/2000

CRAIGE Lab.

SITE PLAN FOR ACCELERATION MEASUREMENT DUE TO RAIL TRAFFIC

(NOT TO SCALE)



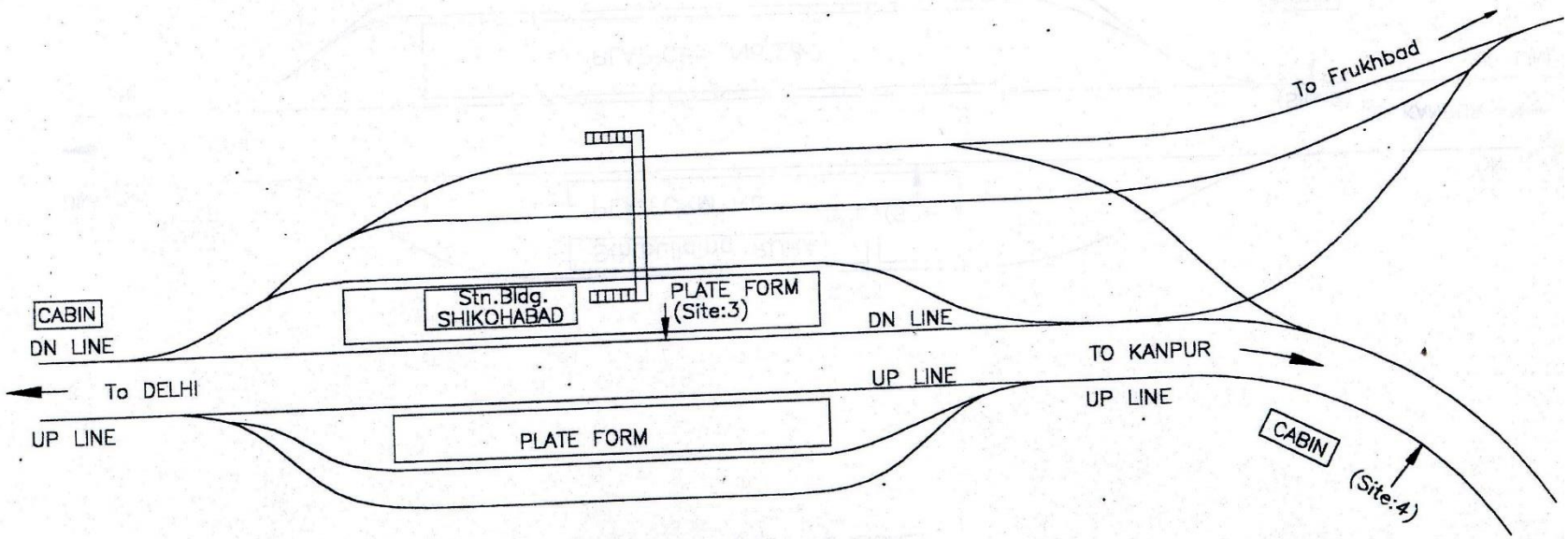
Location of Measurement

(Site:1)___ Km. 1061/22–24

(Site:2)___ Km. 1061/11–13

SITE PLAN FOR ACCELERATION MEASUREMENT DUE TO RAIL TRAFFIC

(NOT TO SCALE)



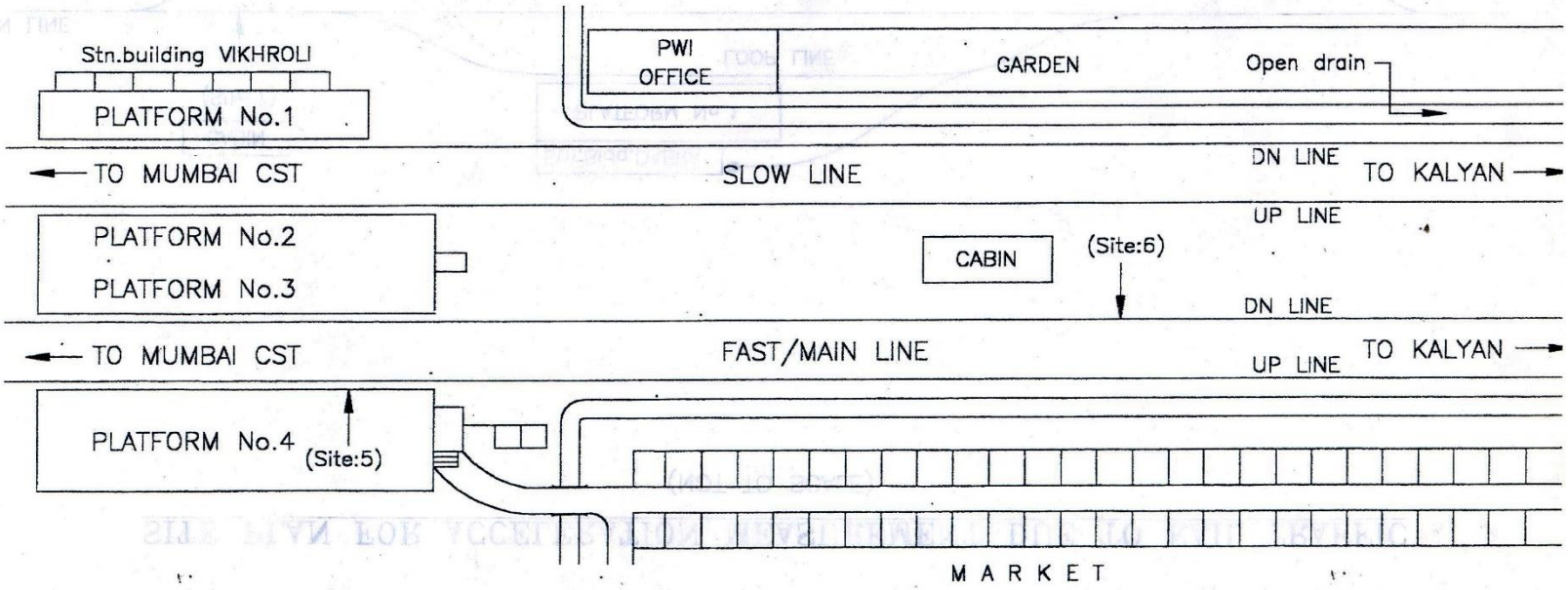
Location of Measurement

(Site:3)___ Km. 1211/34–1212/2

(Site:4)___ Km. 1211/15–17

SITE PLAN FOR ACCELERATION MEASUREMENT DUE TO RAIL TRAFFIC

(NOT TO SCALE)



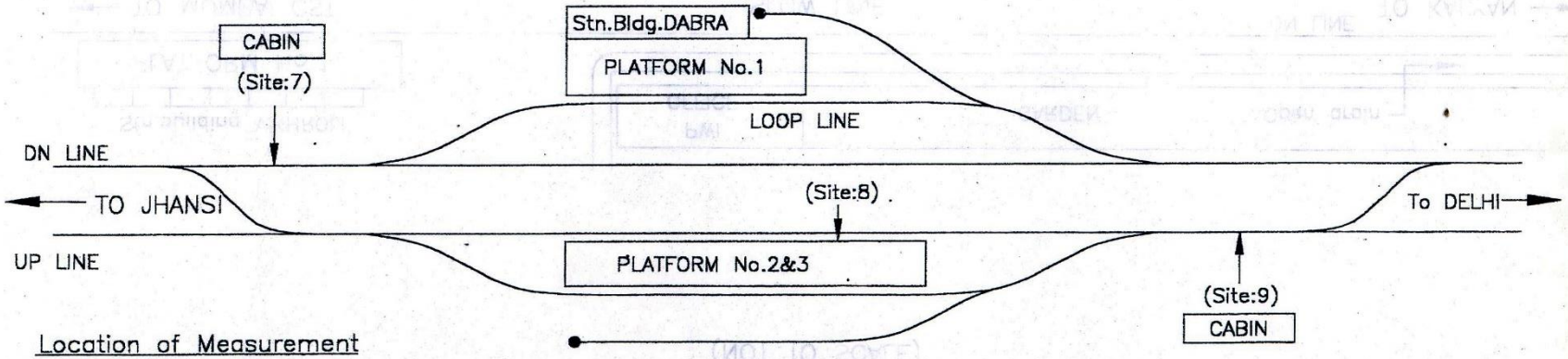
Location of Measurement

(Site:5)___ Km. 22/15–16

(Site:6)___ Km. 22/16–23/1

SITE PLAN FOR ACCELERATION MEASUREMENT DUE TO RAIL TRAFFIC

(NOT TO SCALE)



Location of Measurement

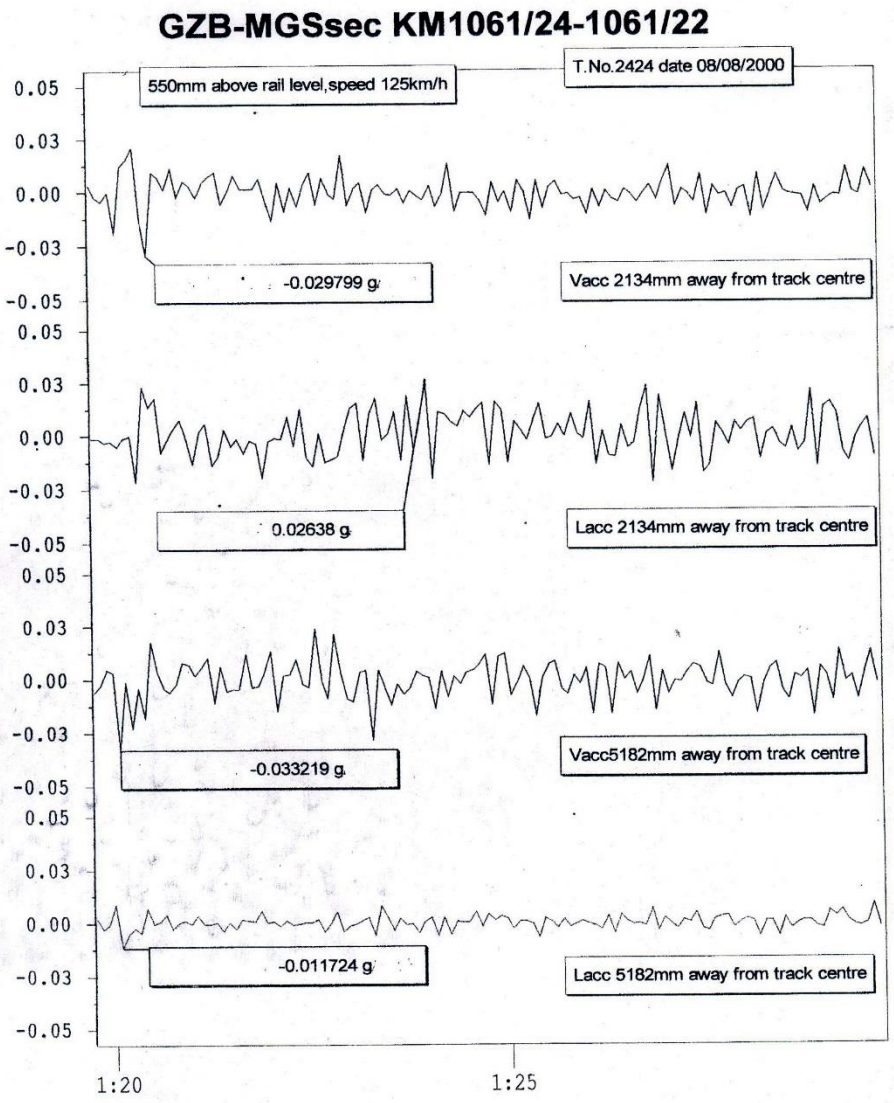
(Site:7)___ Km. 1182/2-4

(Site:8)___ Km. 1182/21-23

(Site:9)___ Km. 1183/1-3

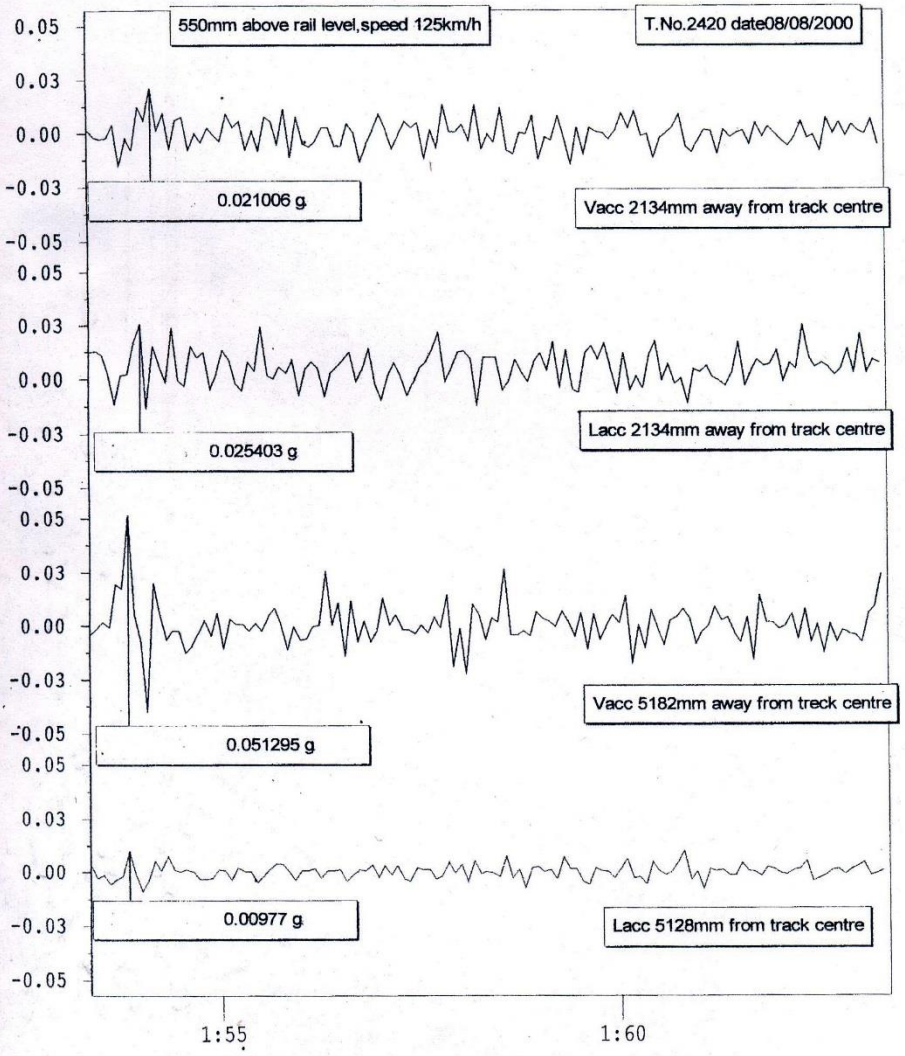
Fig 3.43

EFFECT OF VIBRATION DUE TO RAIL TRAFFIC ALONG TRACK



EFFECT OF VIBRATION DUE TO RAIL TRAFFIC ALONG TRACK

GZB-MGSsec KM1061/24-1061/22



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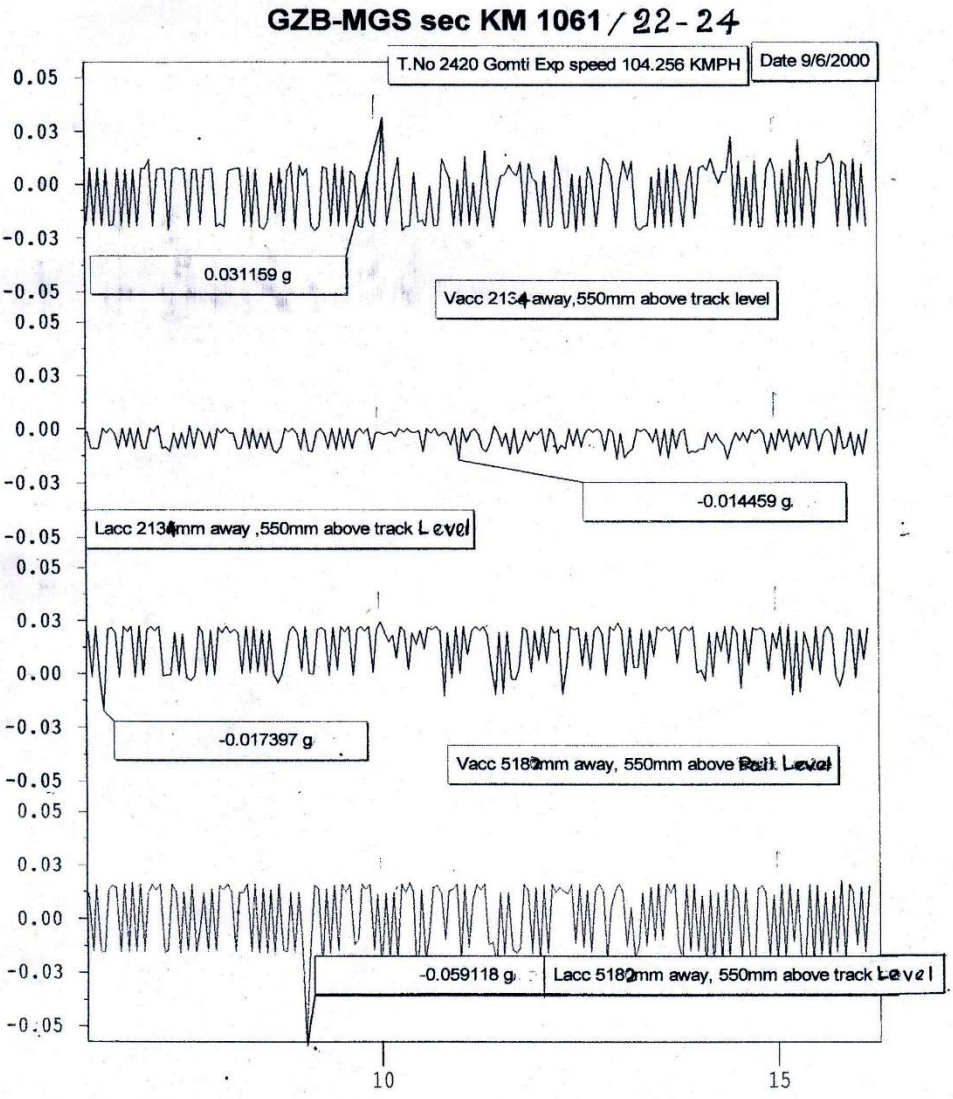

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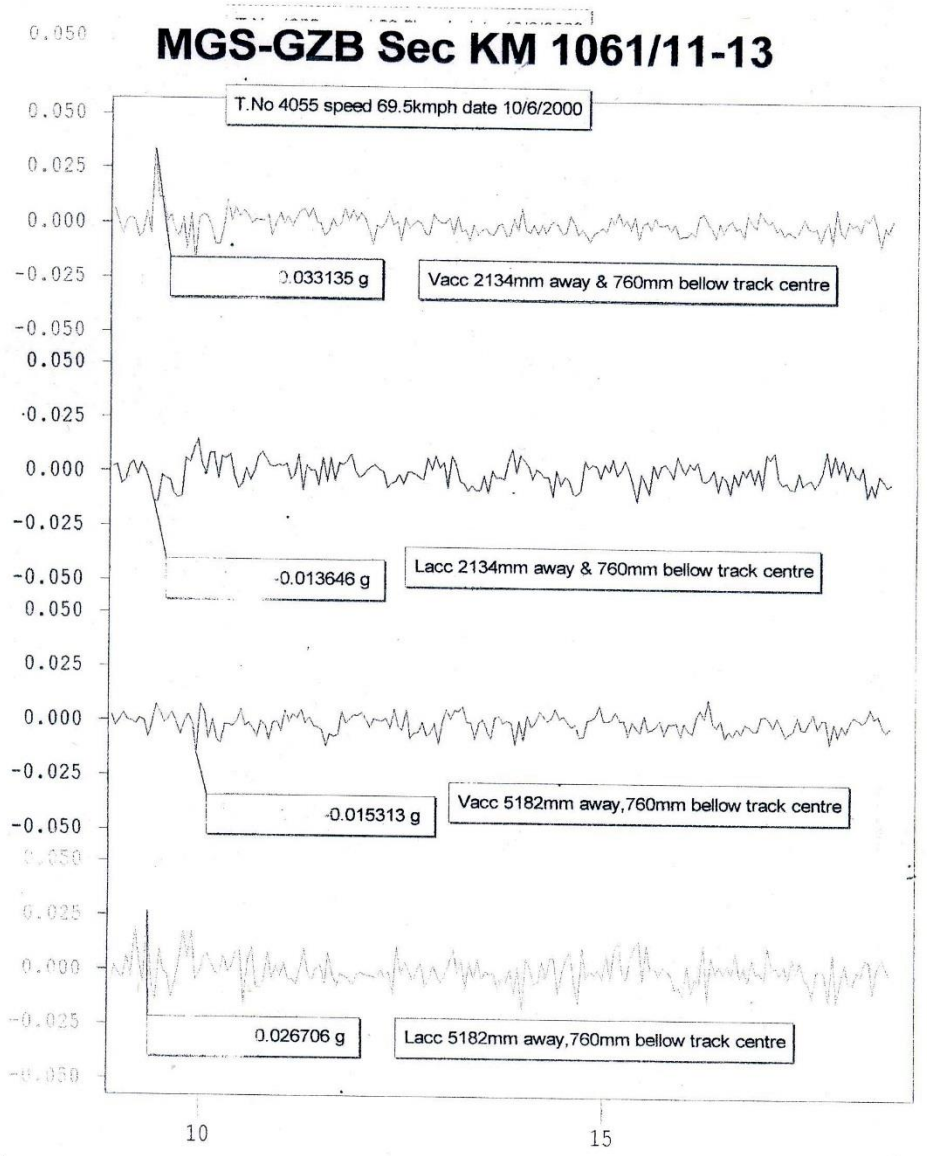

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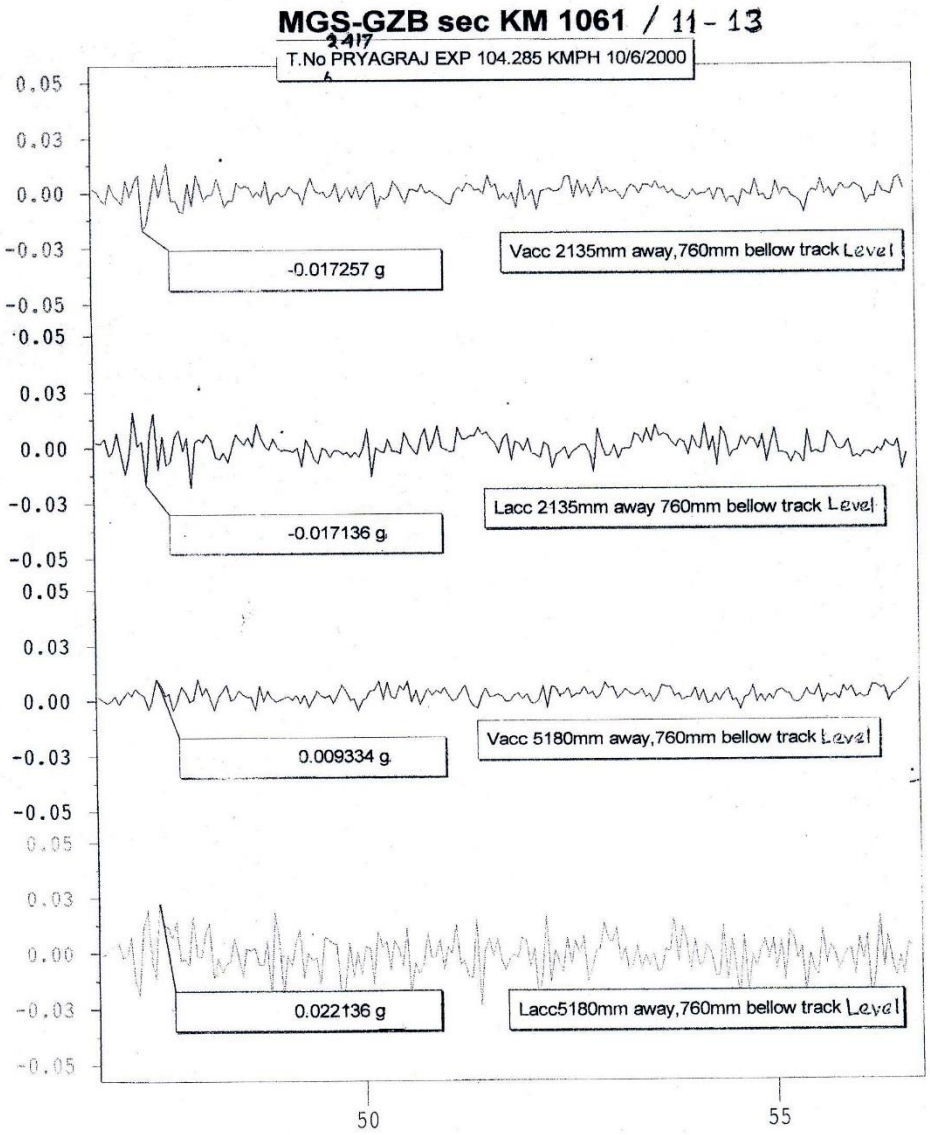

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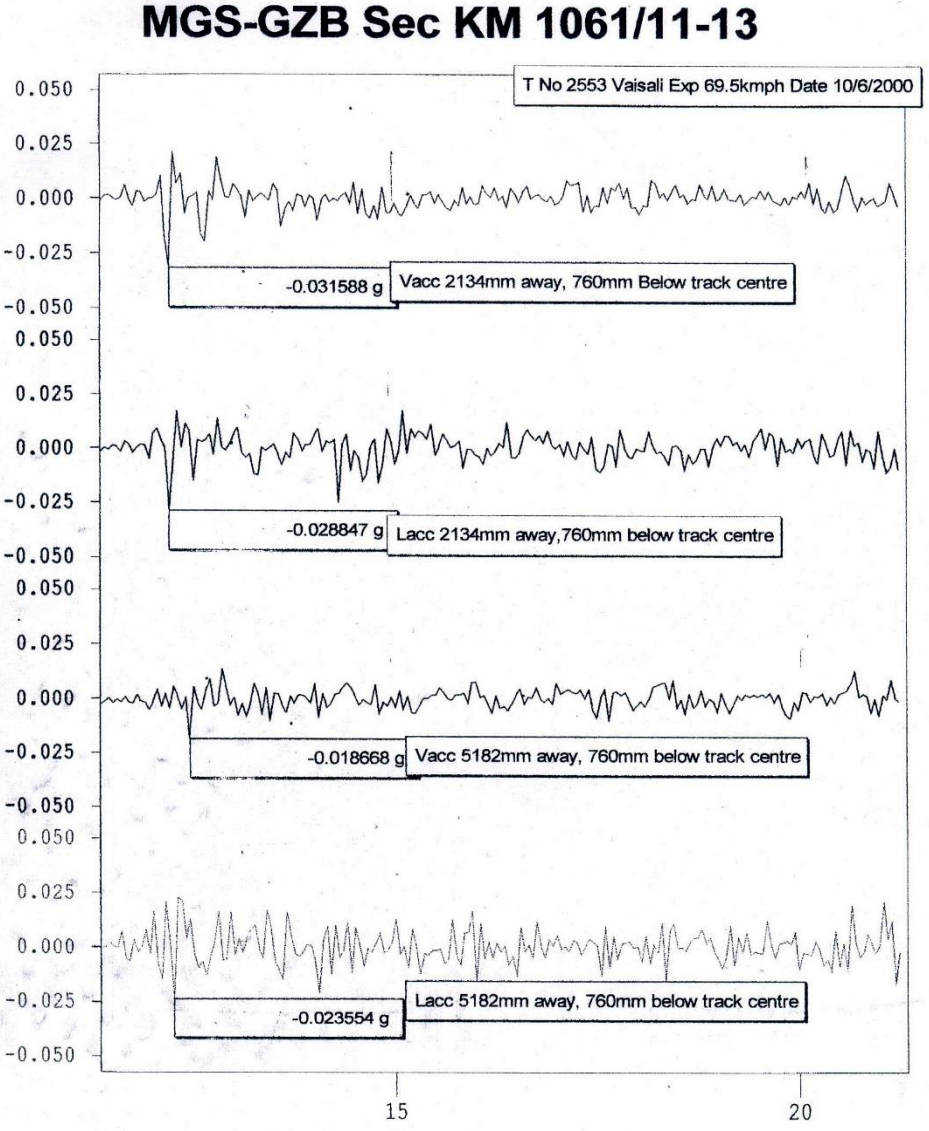

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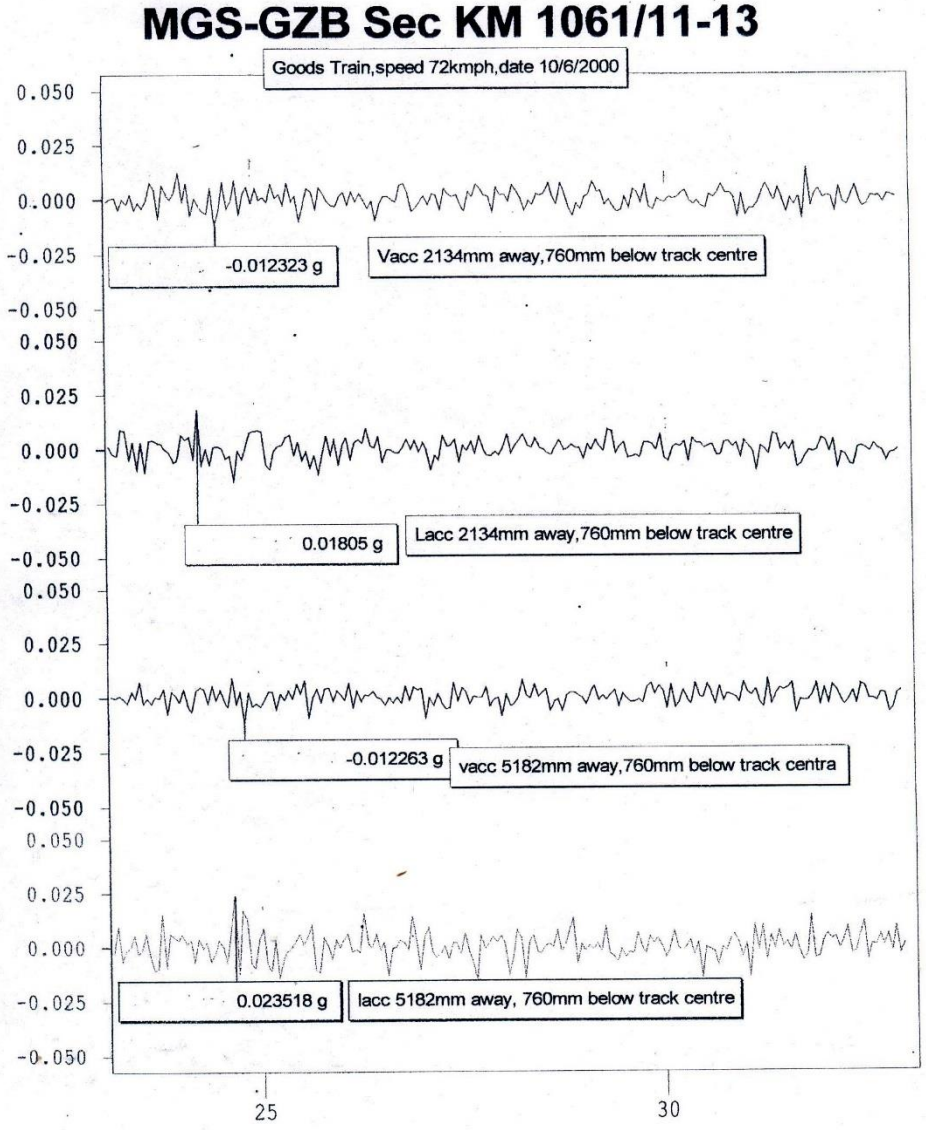

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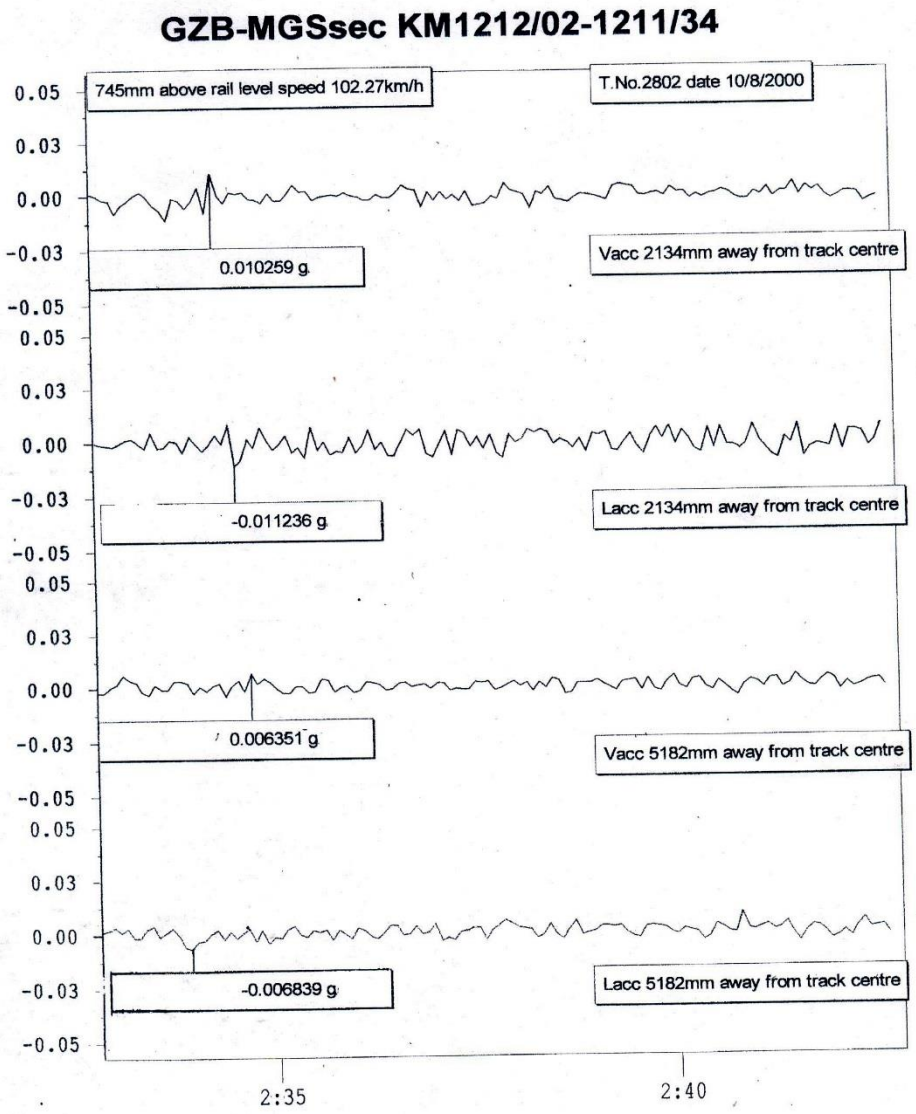

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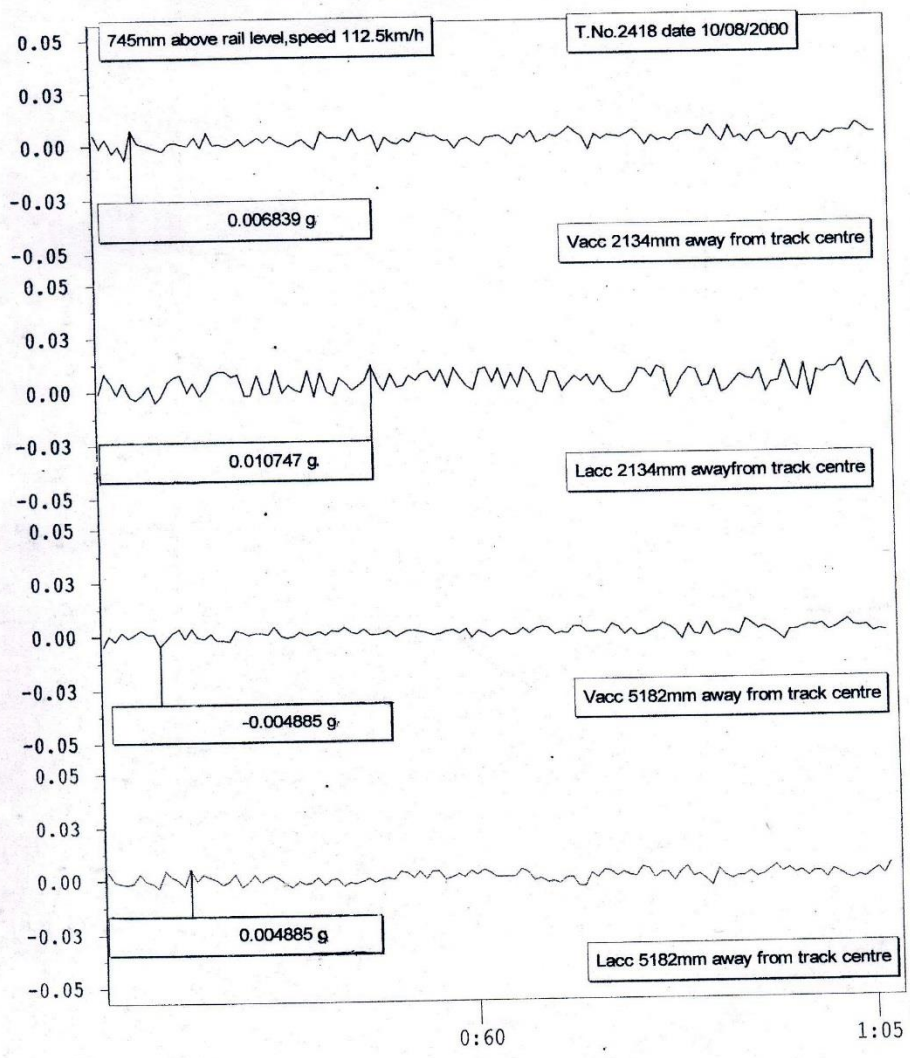

EFFECT OF VIBRATION DUE TO RAIL TRAFFIC ALONG TRACK

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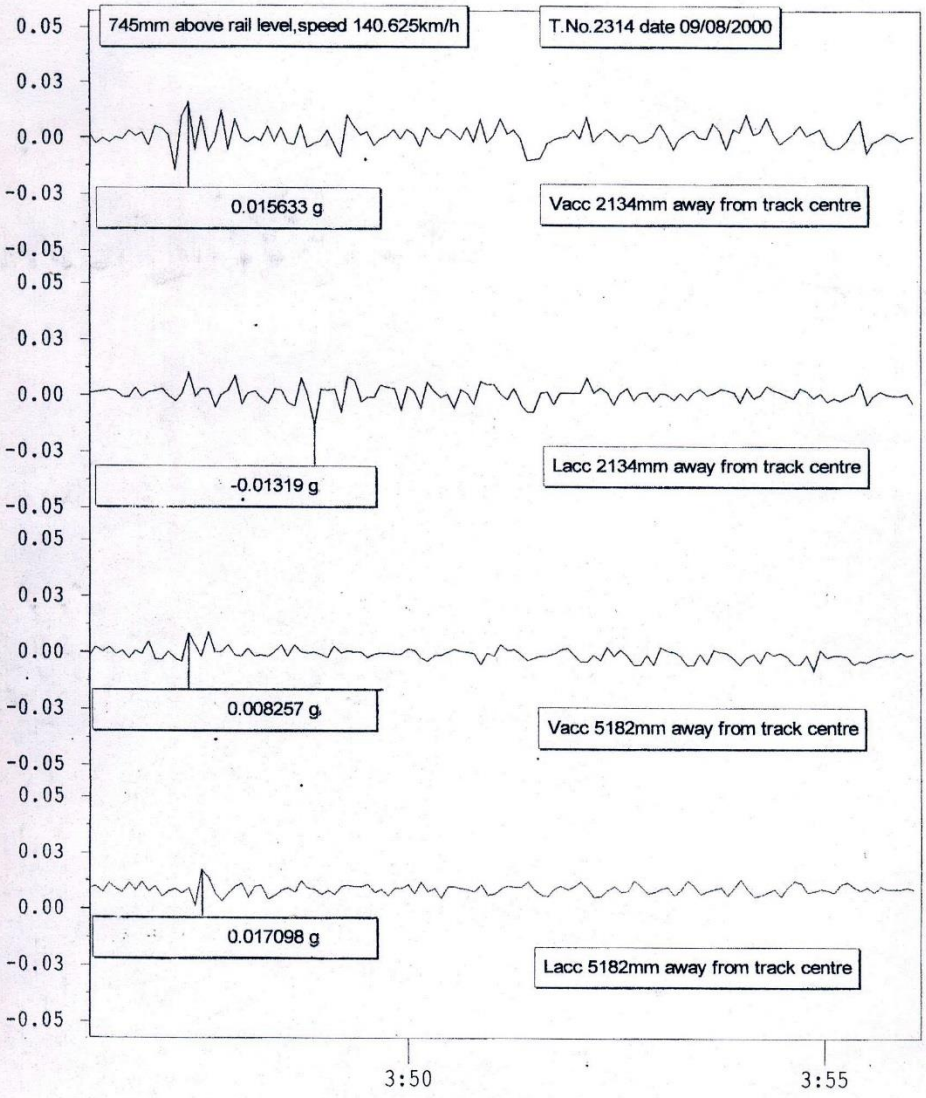

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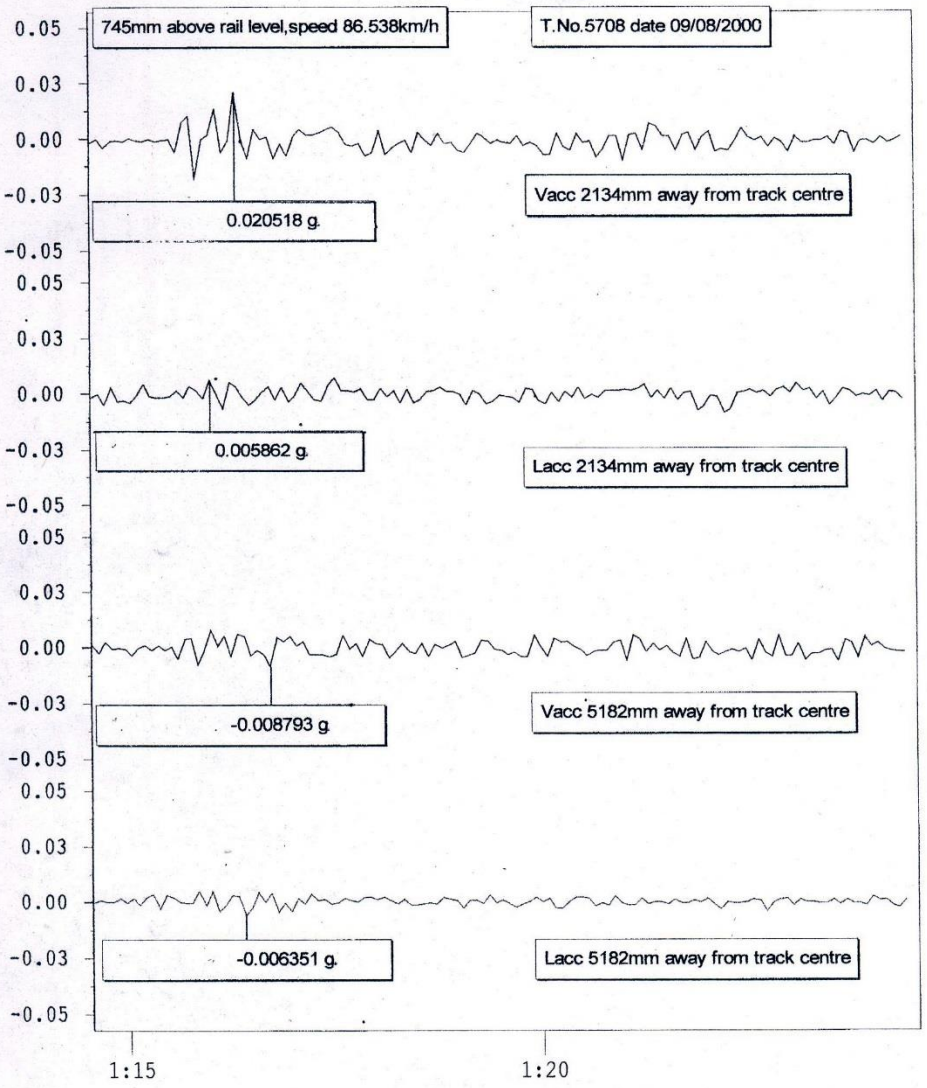
GZB-MGSsec KM1212/02-1211/34



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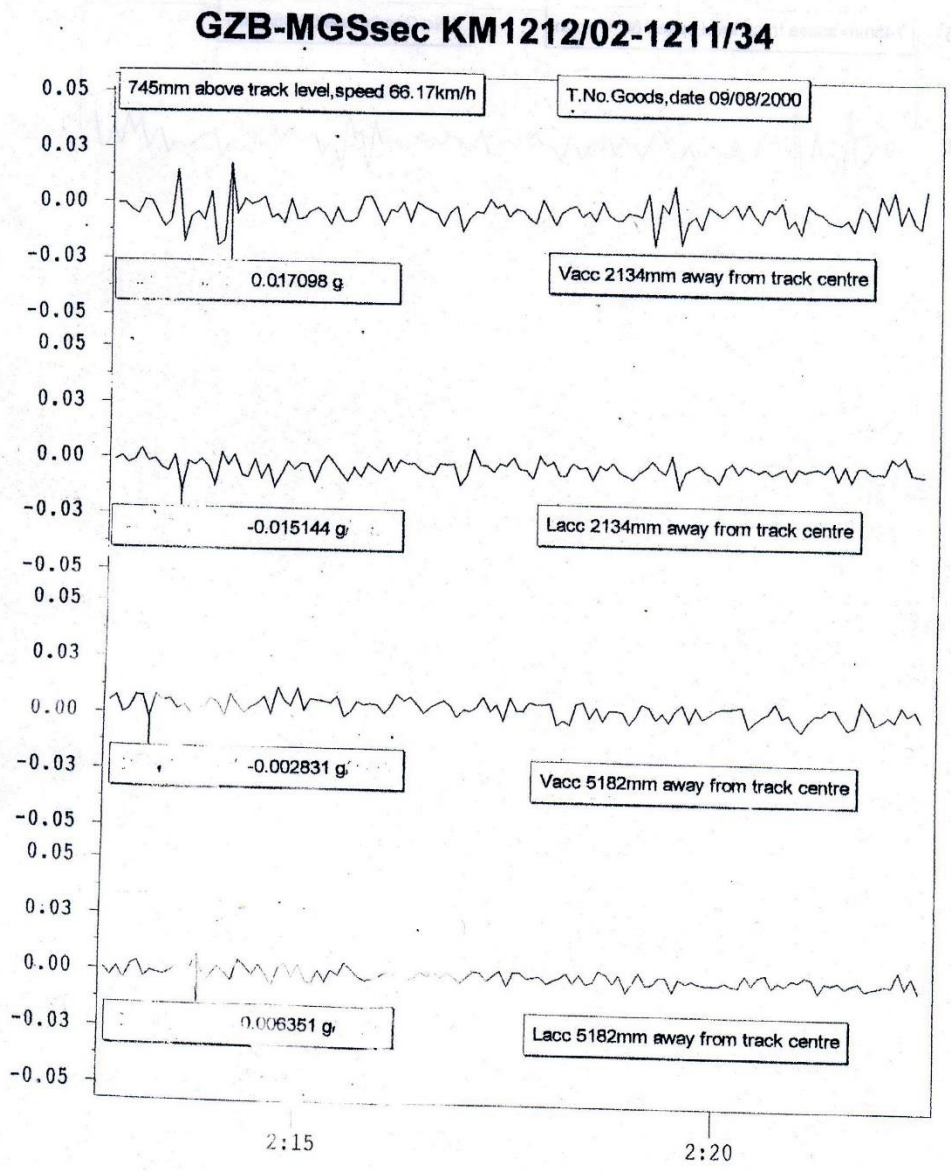
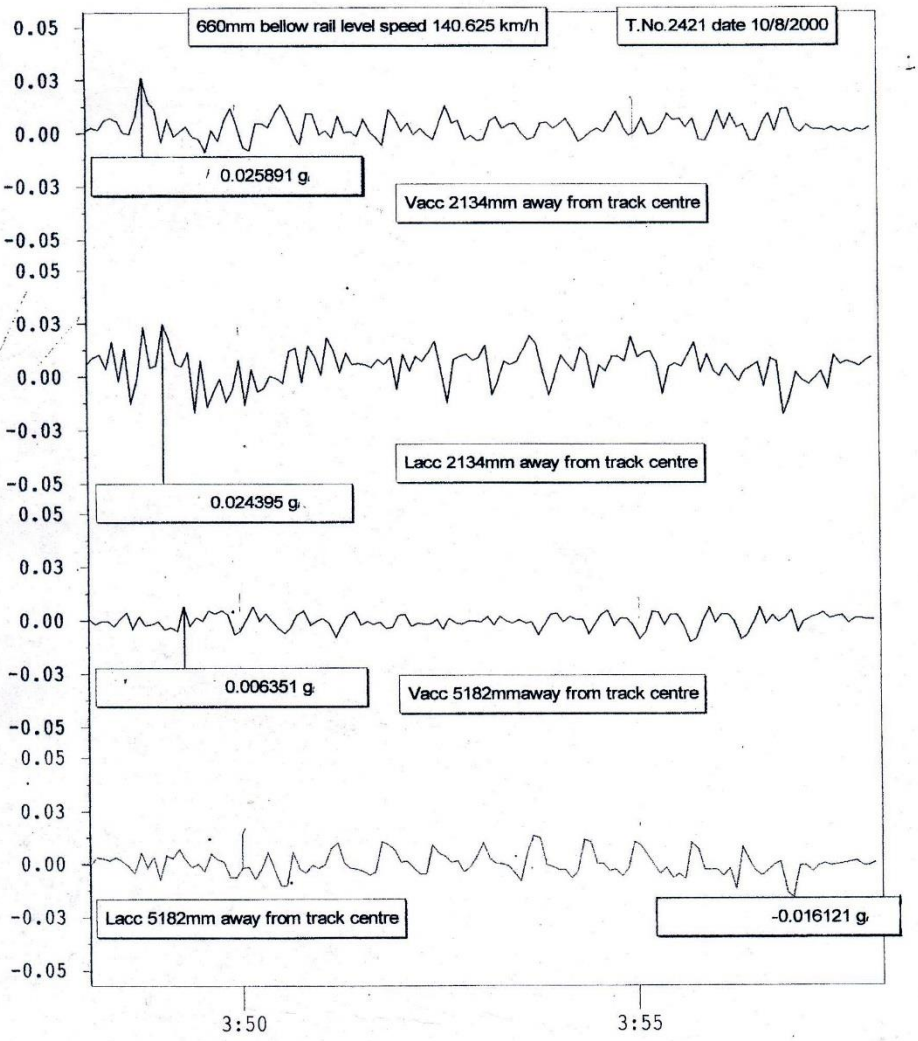


EFFECT OF VIBRATIONS DUE TO RAIL TRAFFIC ALONG TRACK

MGS-GZBsec KM 1211/15-1211/17



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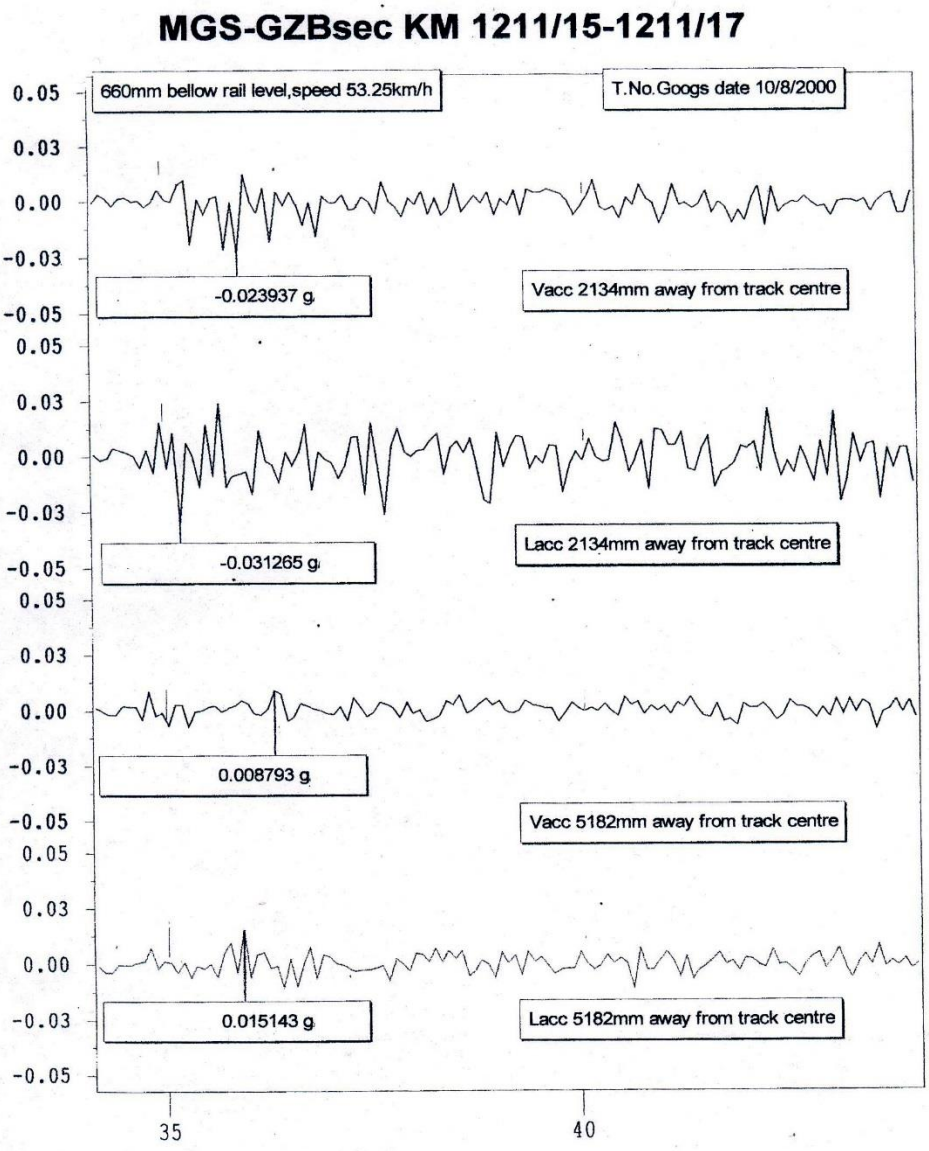
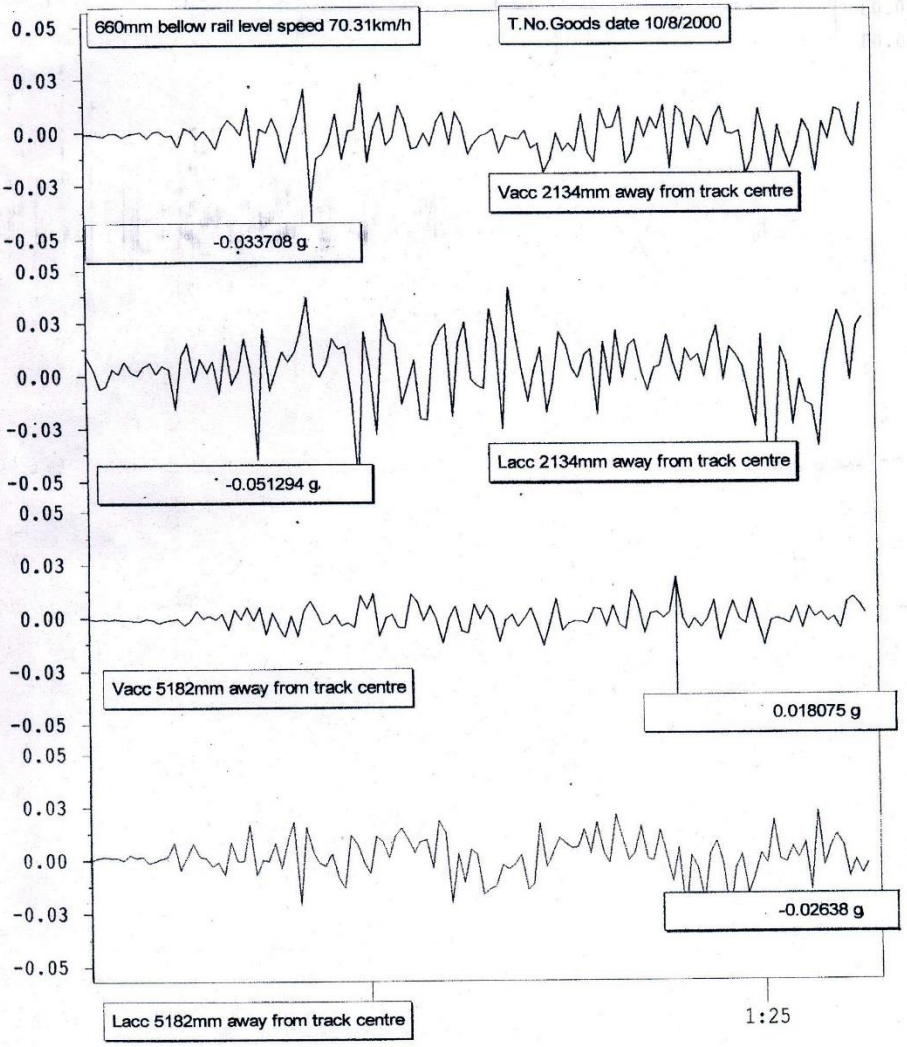


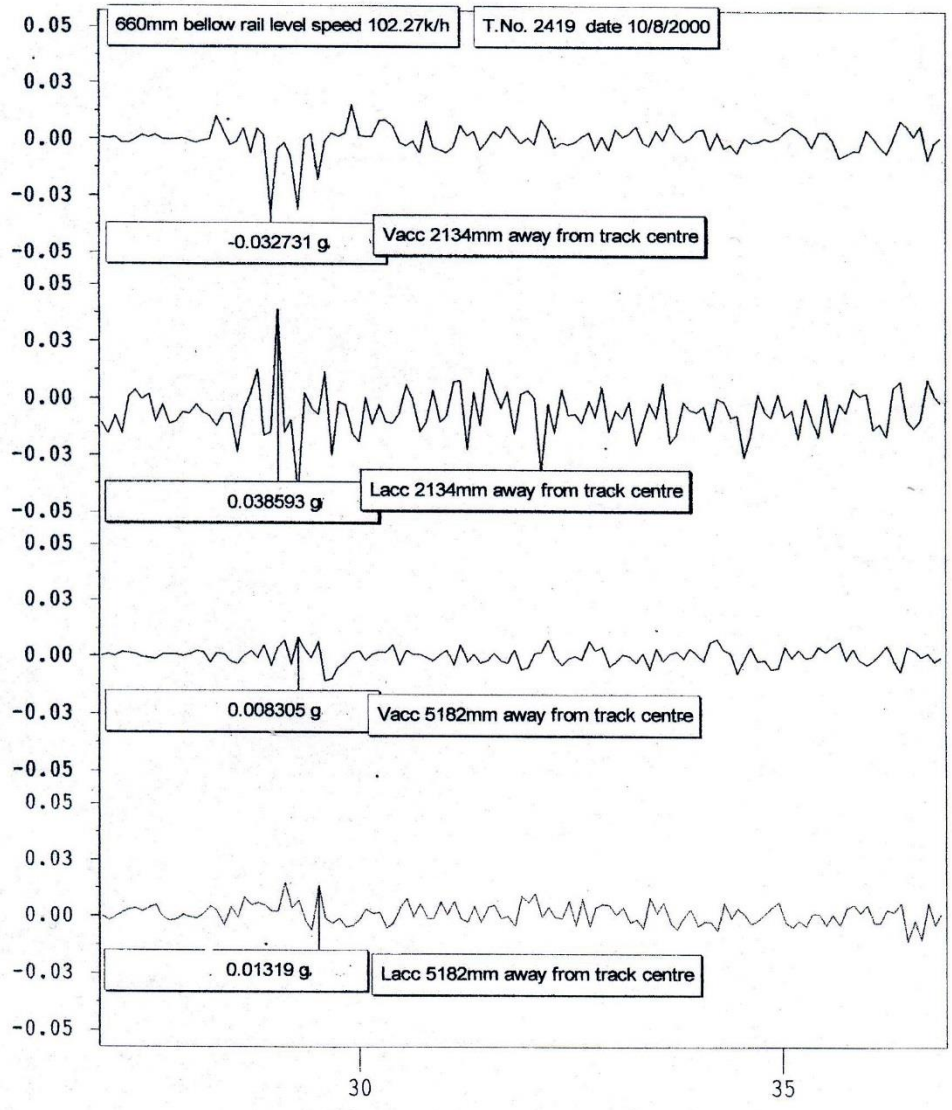
EFFECT OF VIBRATION DUE TO RAIL TRAFFIC ALONG TRACK

MGS-GZBsec KM 1211/15-1211/17



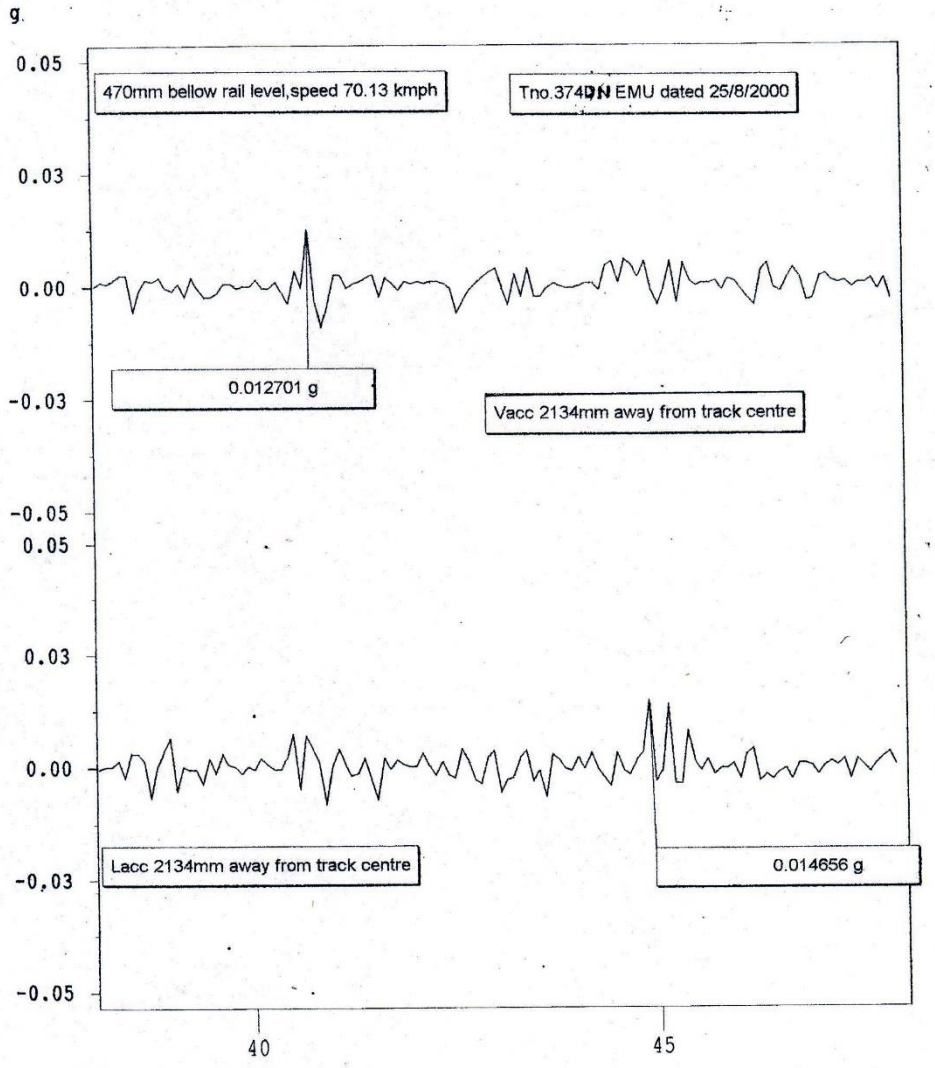
EFFECT OF VIBRATION DUE TO RAIL TRAFFIC ALONG TRACK

MGS-GZBsec KM 1211/15-1211/17



VIBRATION DUE TO RAIL TRAFFIC ALONG TRACK

M.CST-KALYAN SEC 23/1 -22/16



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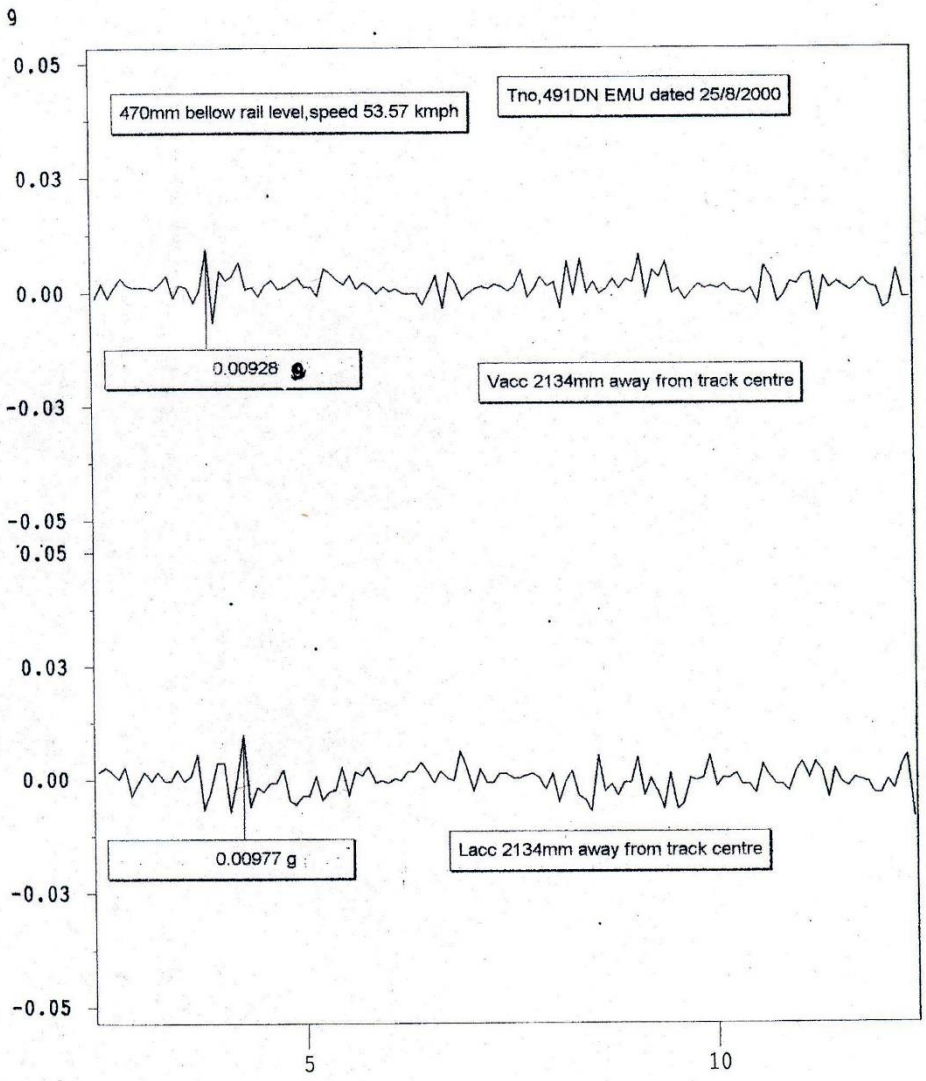
M.CST-KALYAN SEC 23/1 -22/16



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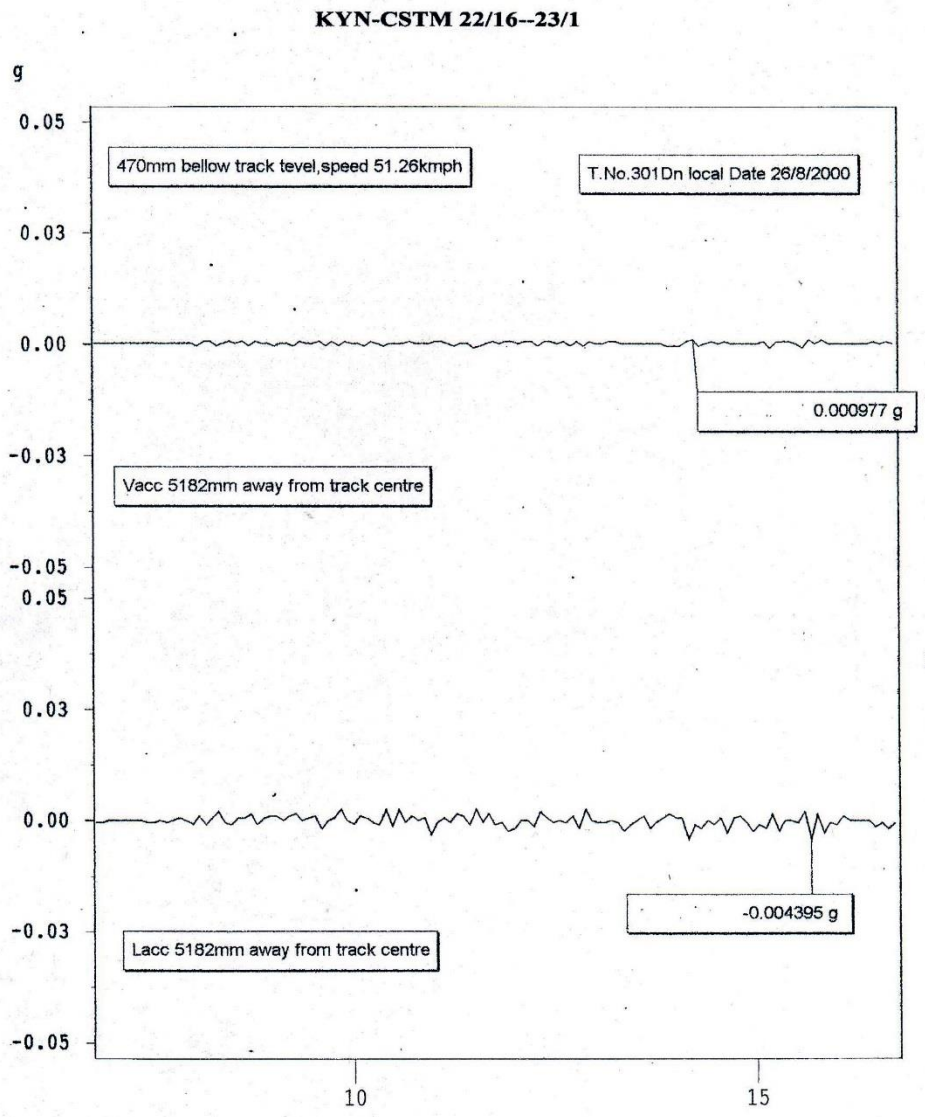

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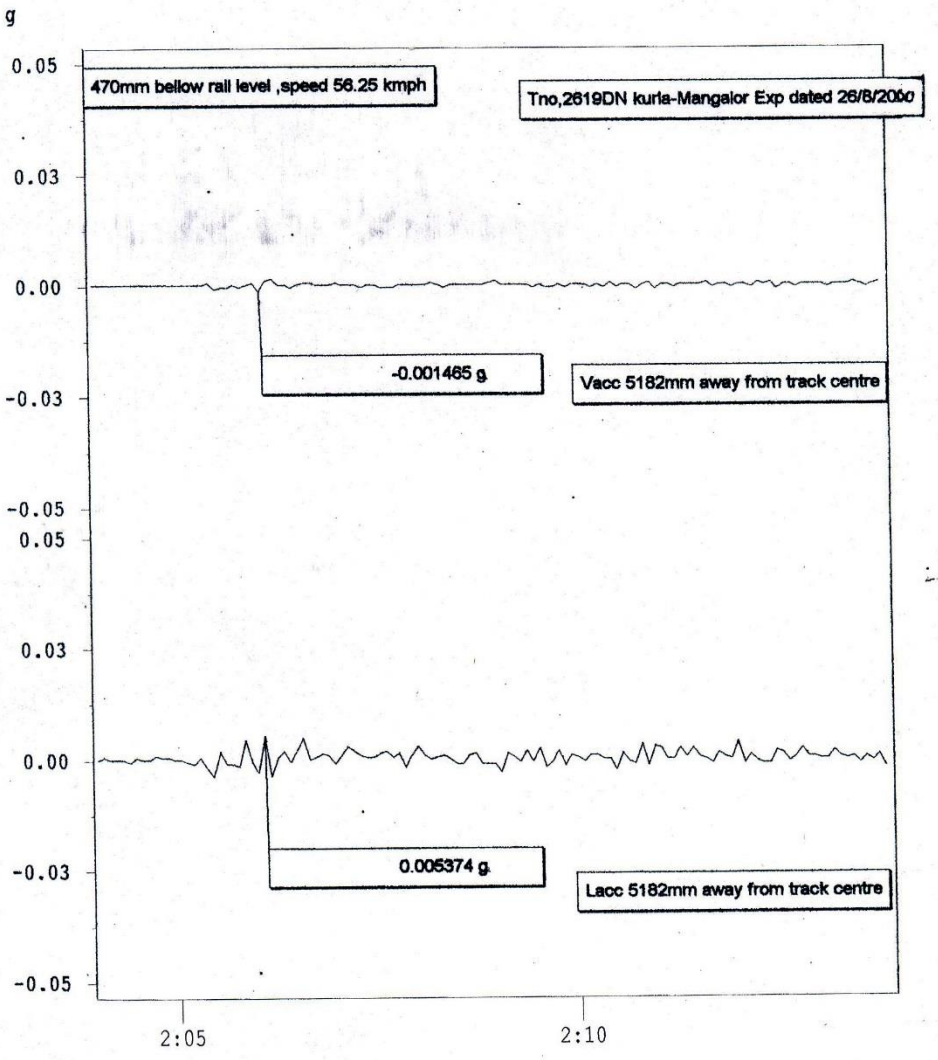

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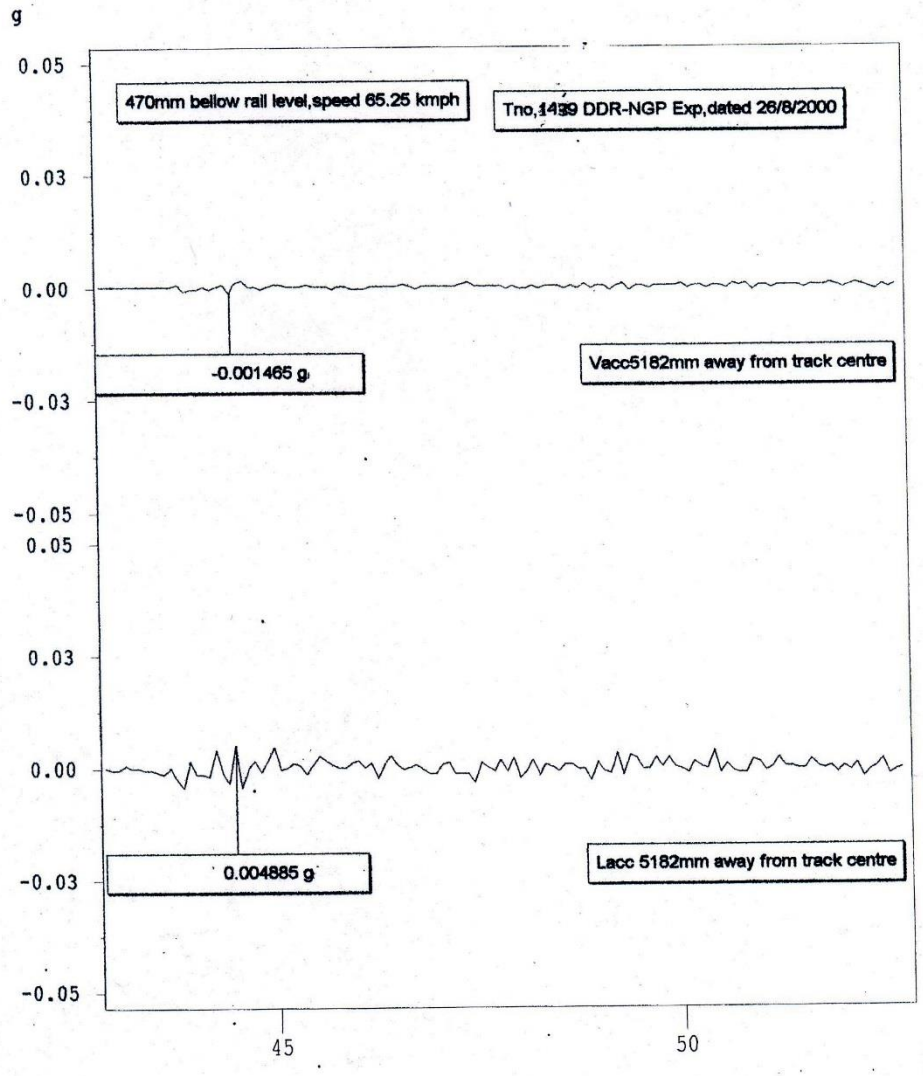

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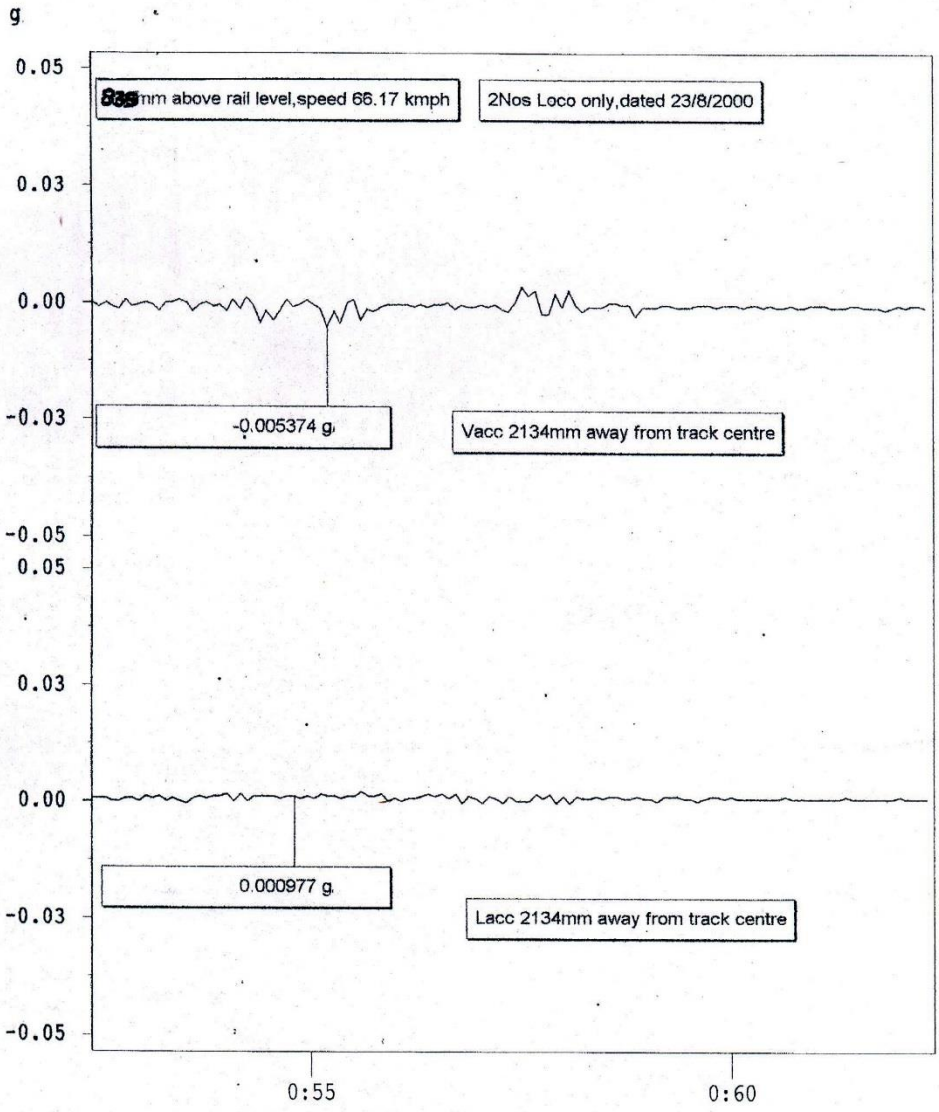

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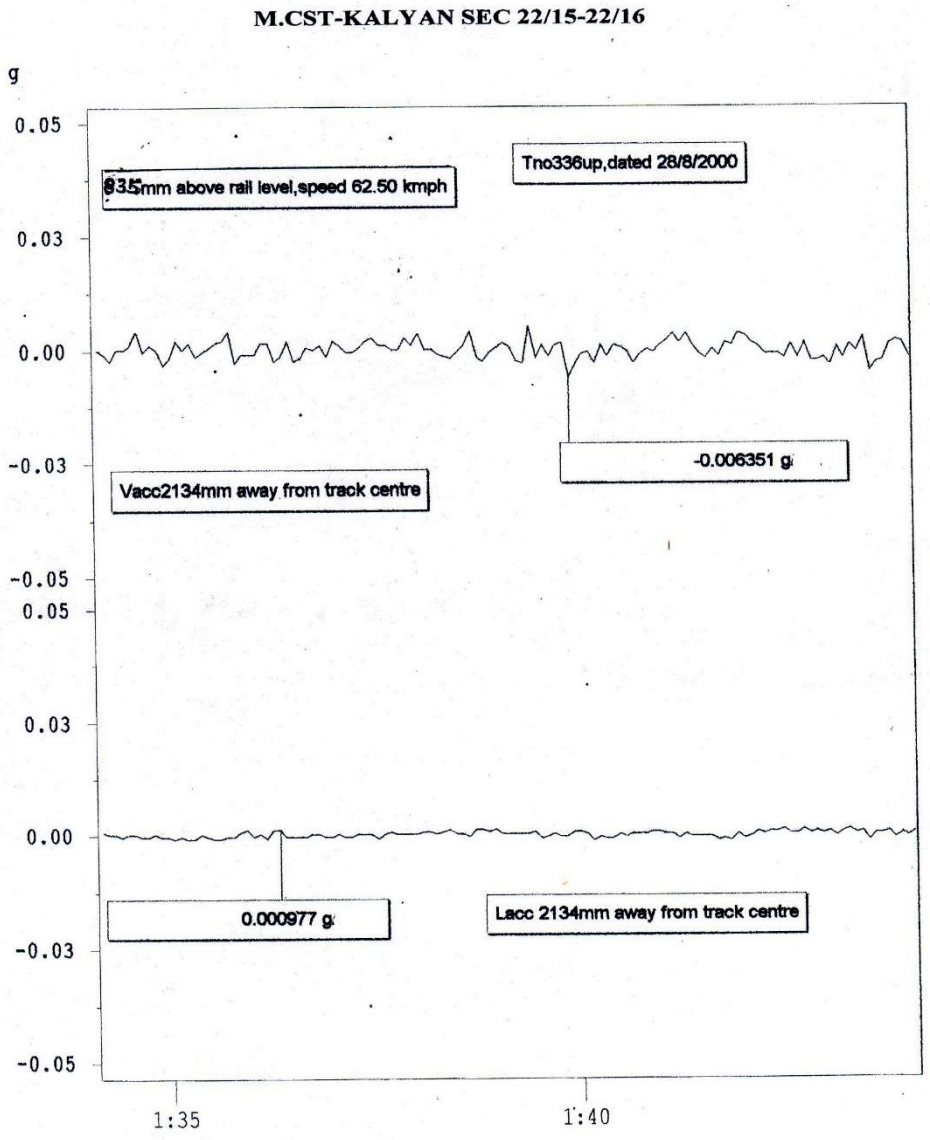
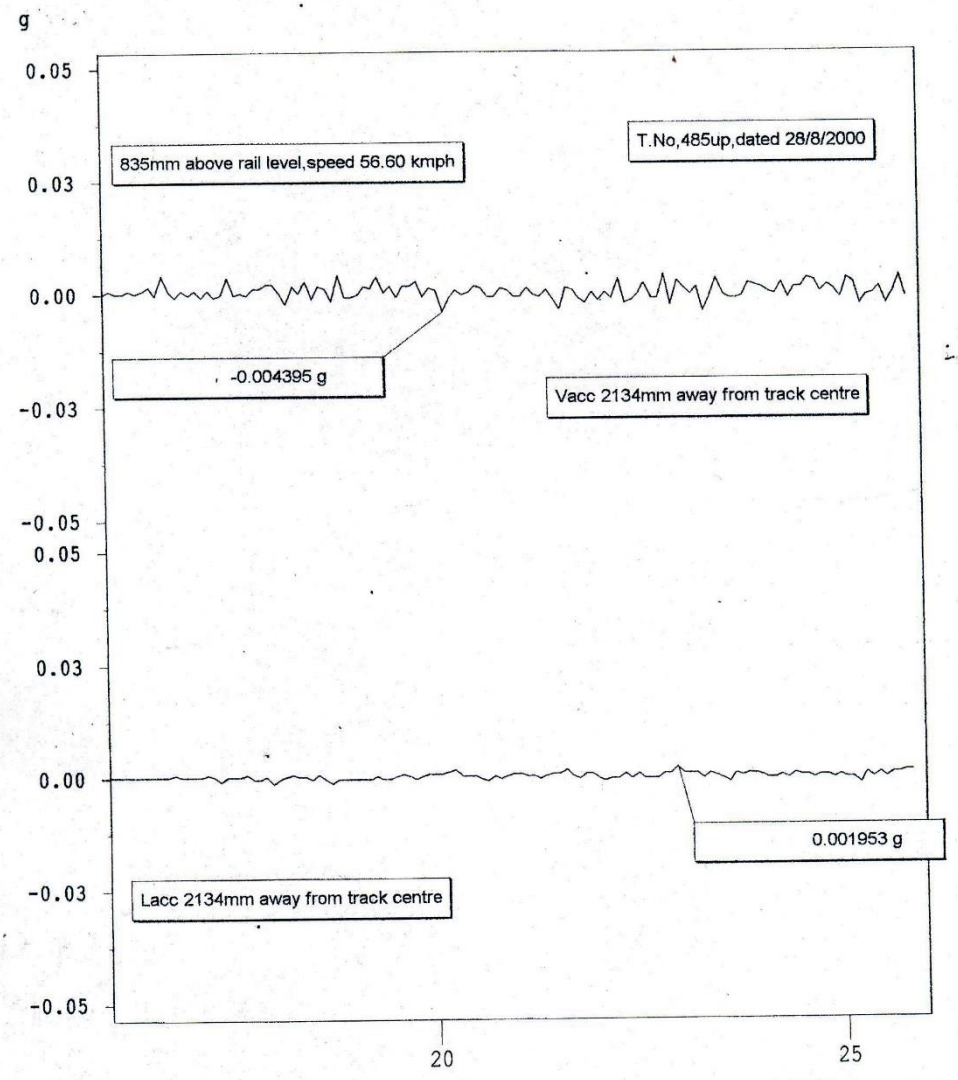


VIBRATION DUE TO RAIL TRAFFIC ALONG TRACK

KYN-CSTM 22/15-22/16



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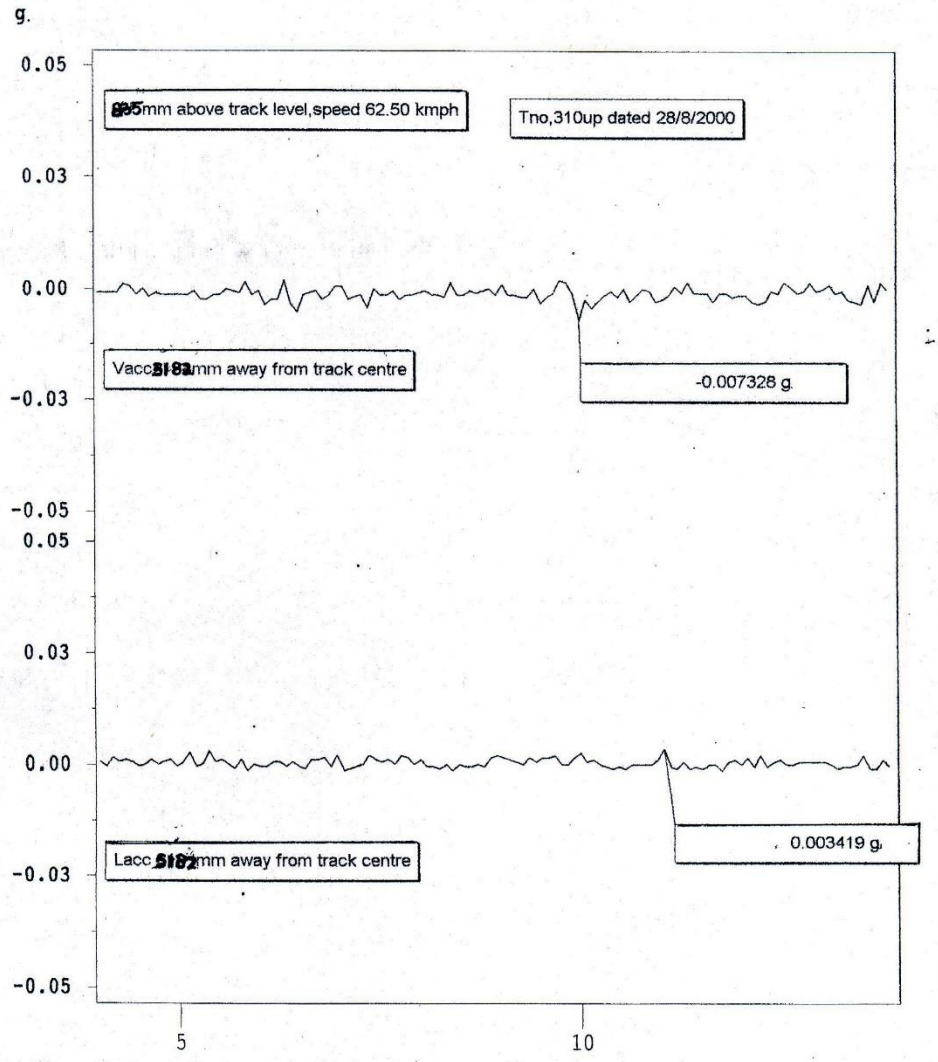

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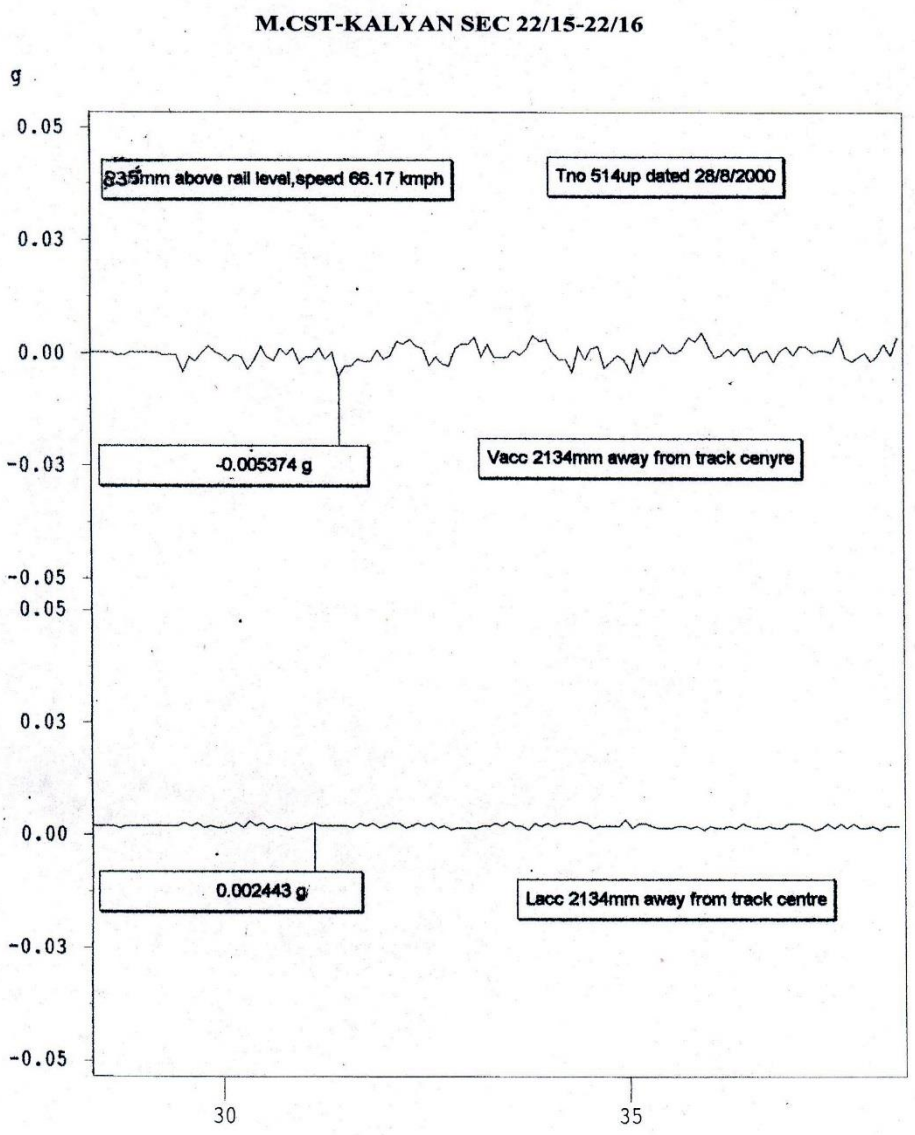
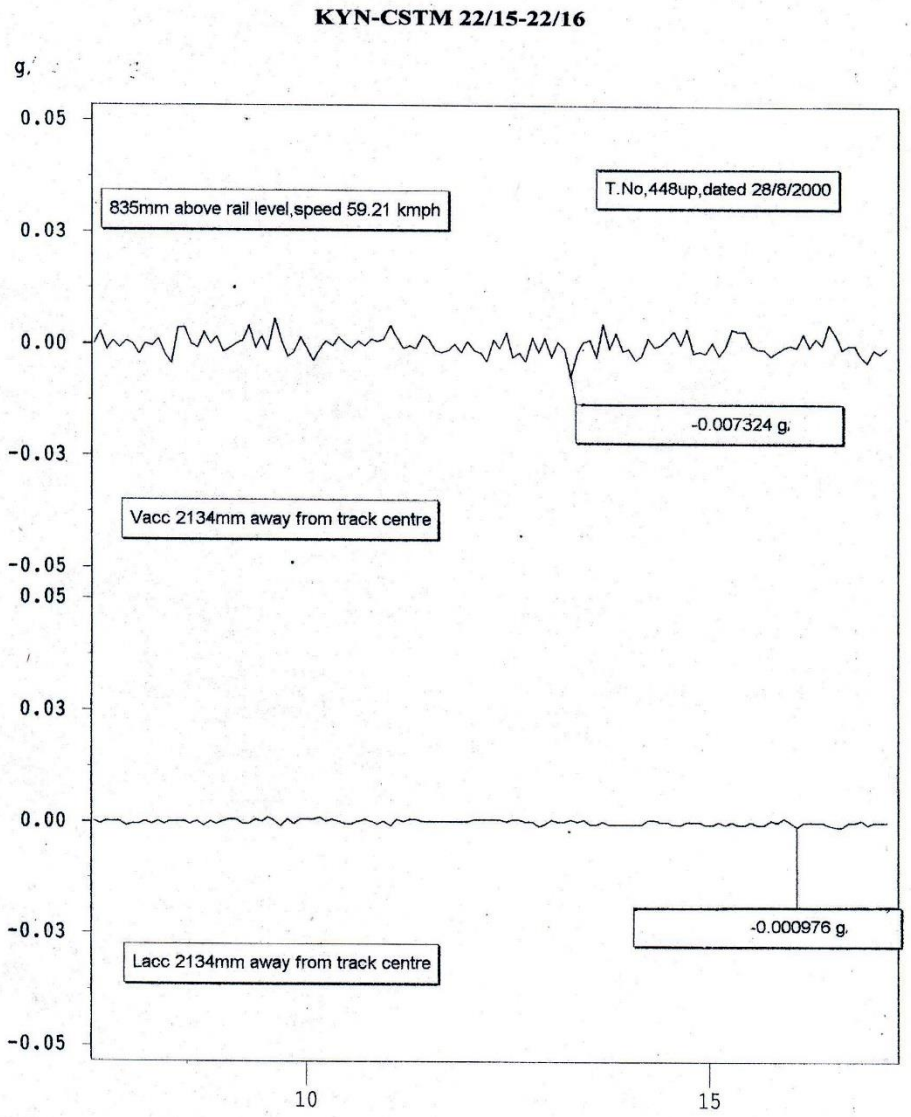


VIBRATION DUE TO RAIL TRAFFIC ALONG TRACK



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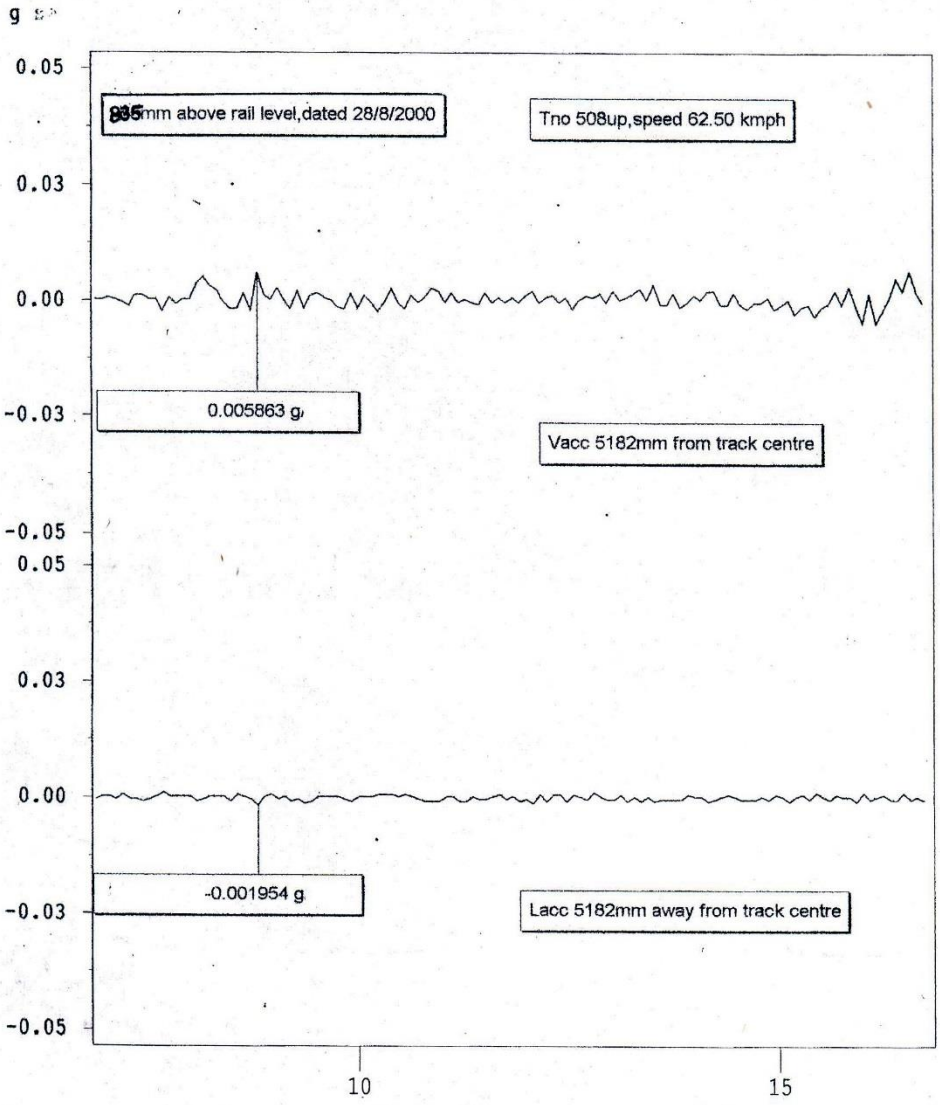
M.CST-KALYAN SEC 22/15-22/16



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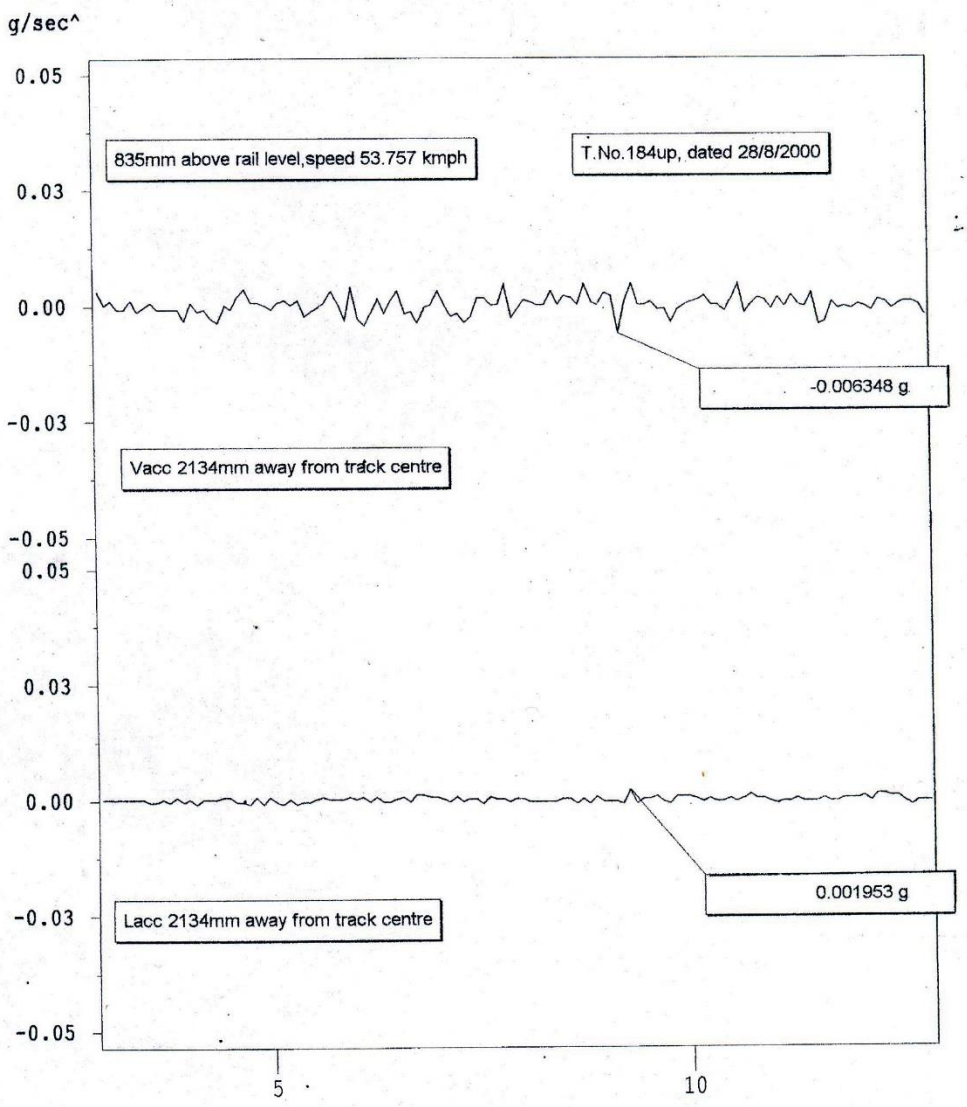
KYN-CSTM 22/15-22/16



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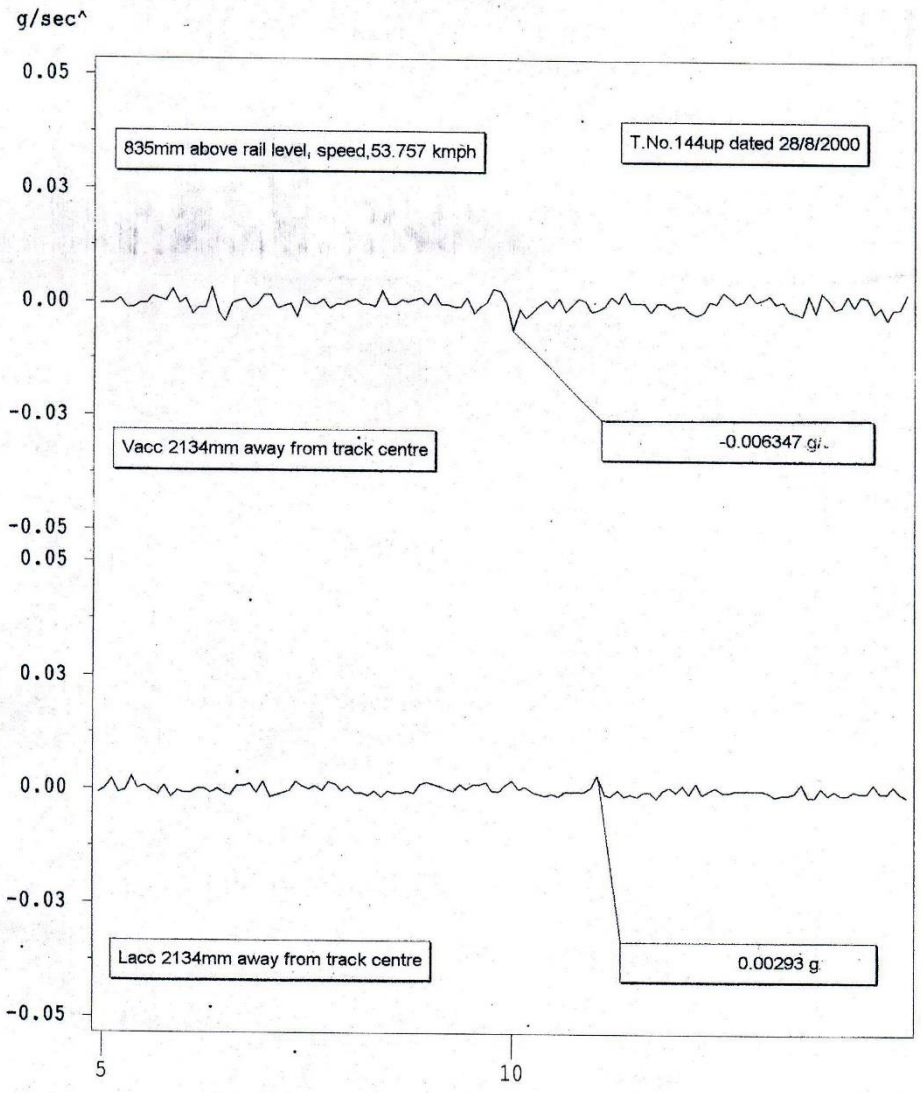

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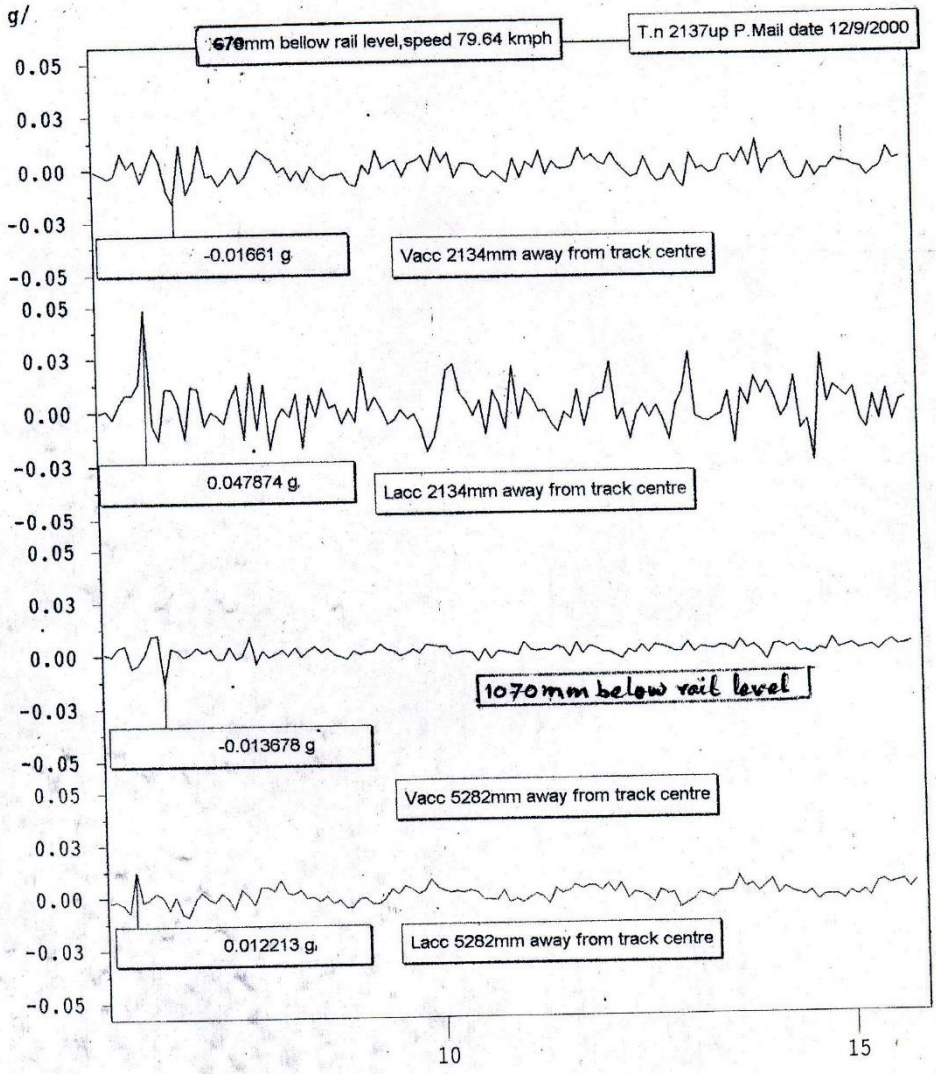
JHS-GWL KM 1182/2-1182/4



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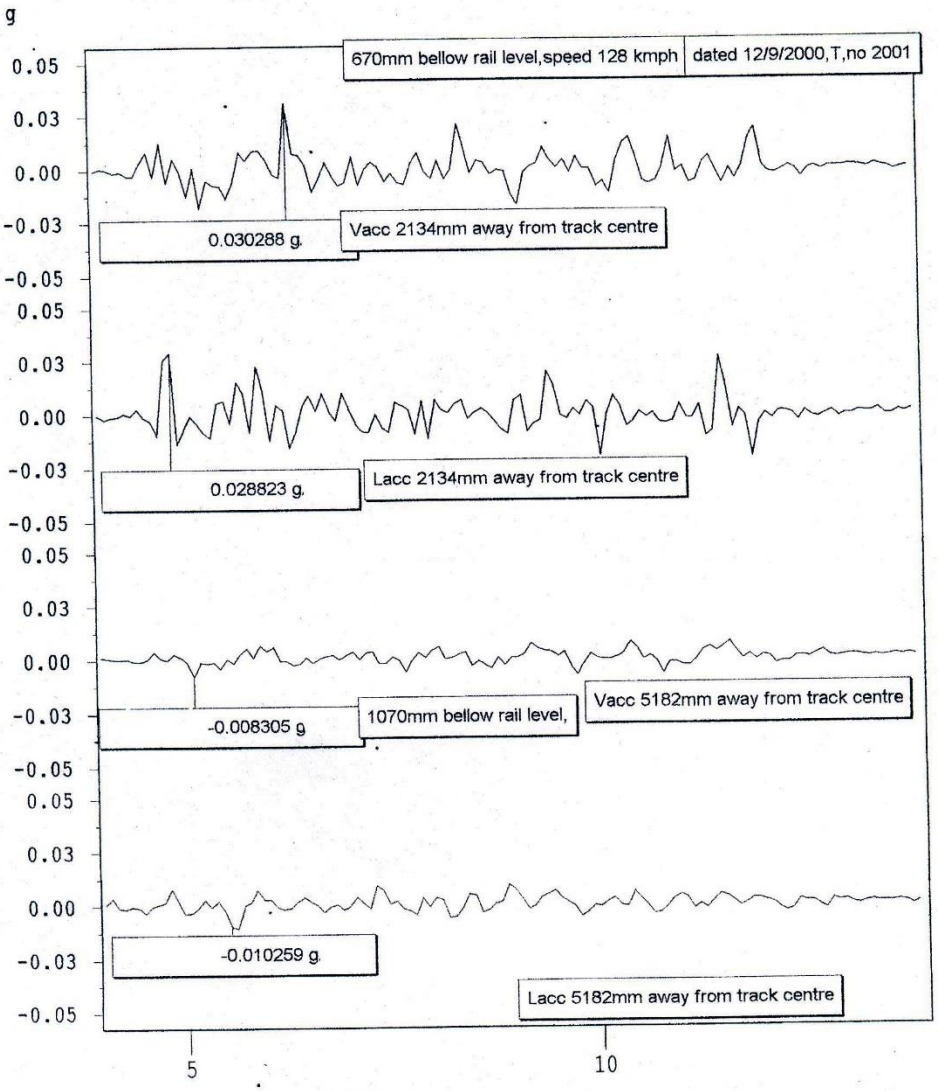

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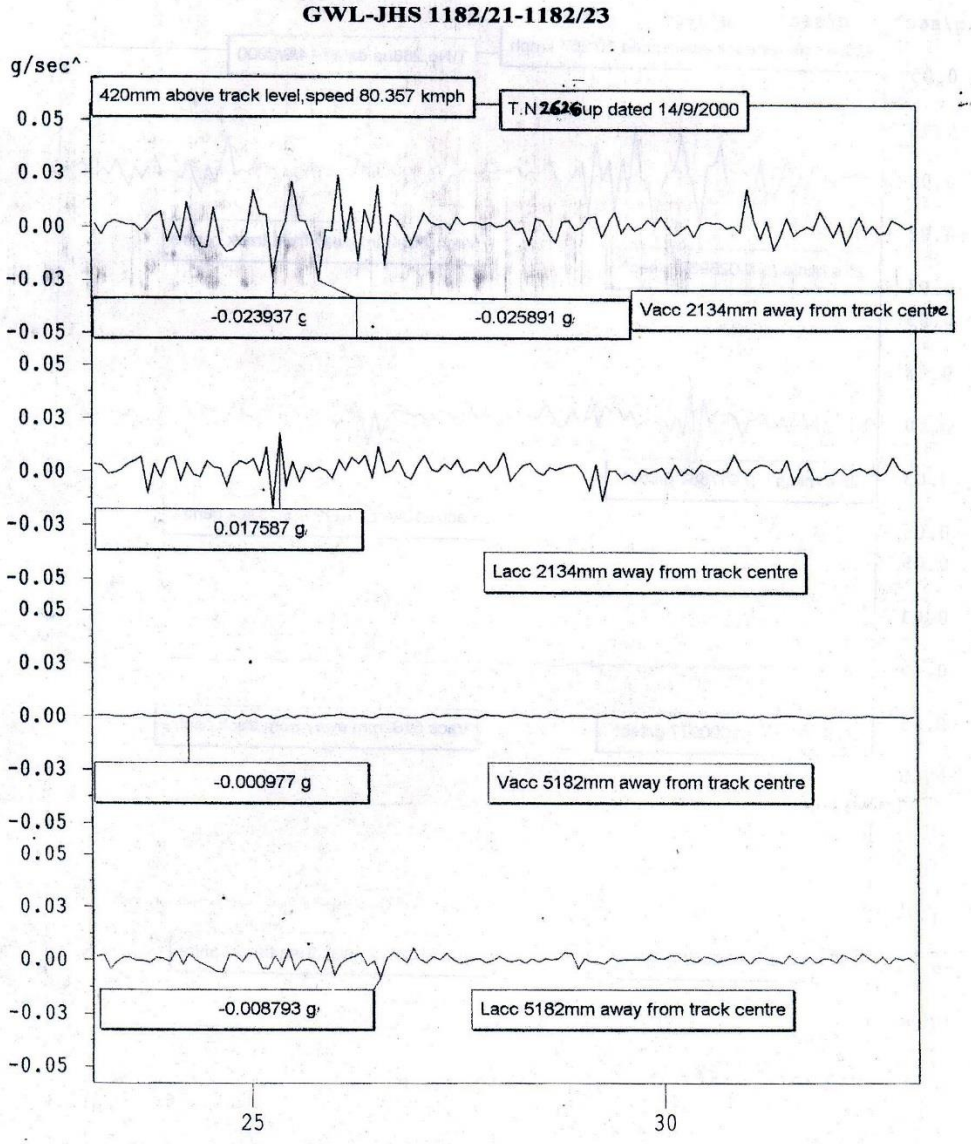

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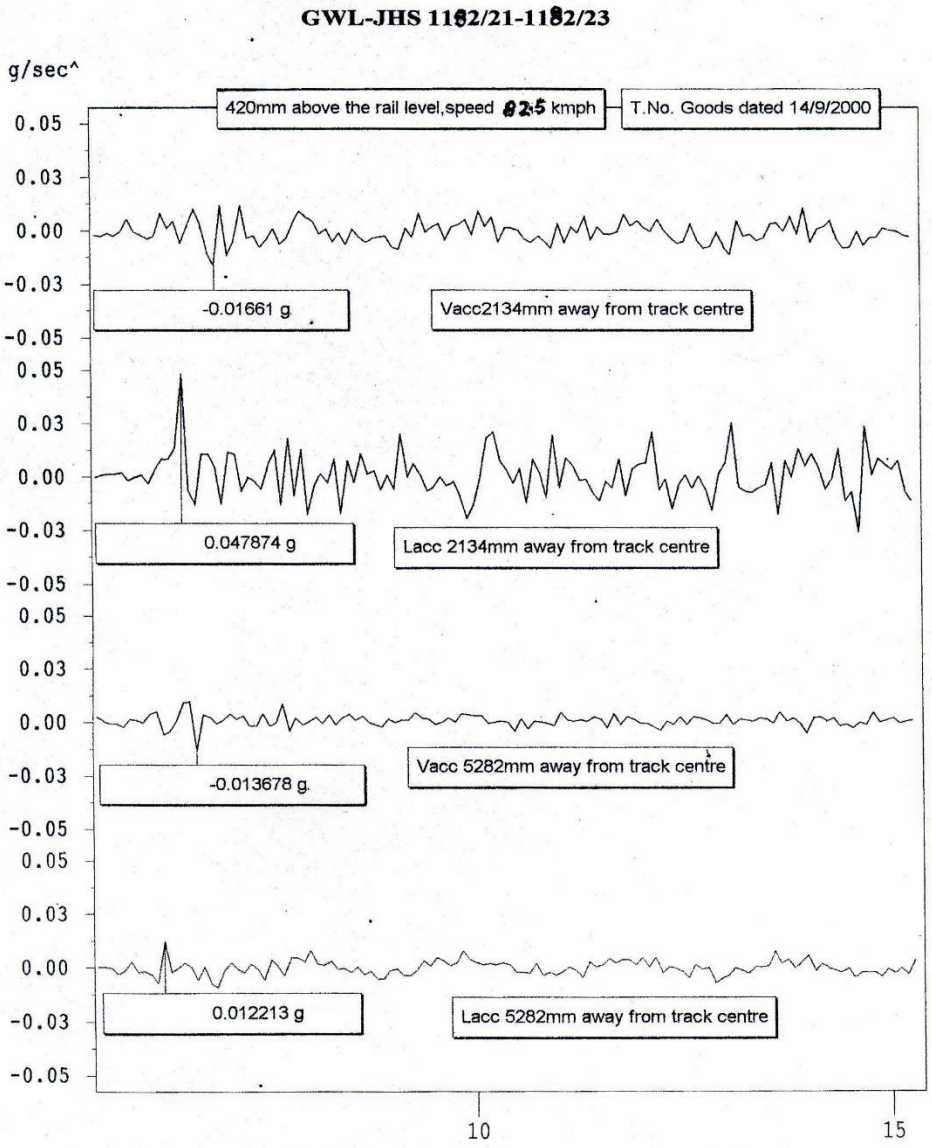

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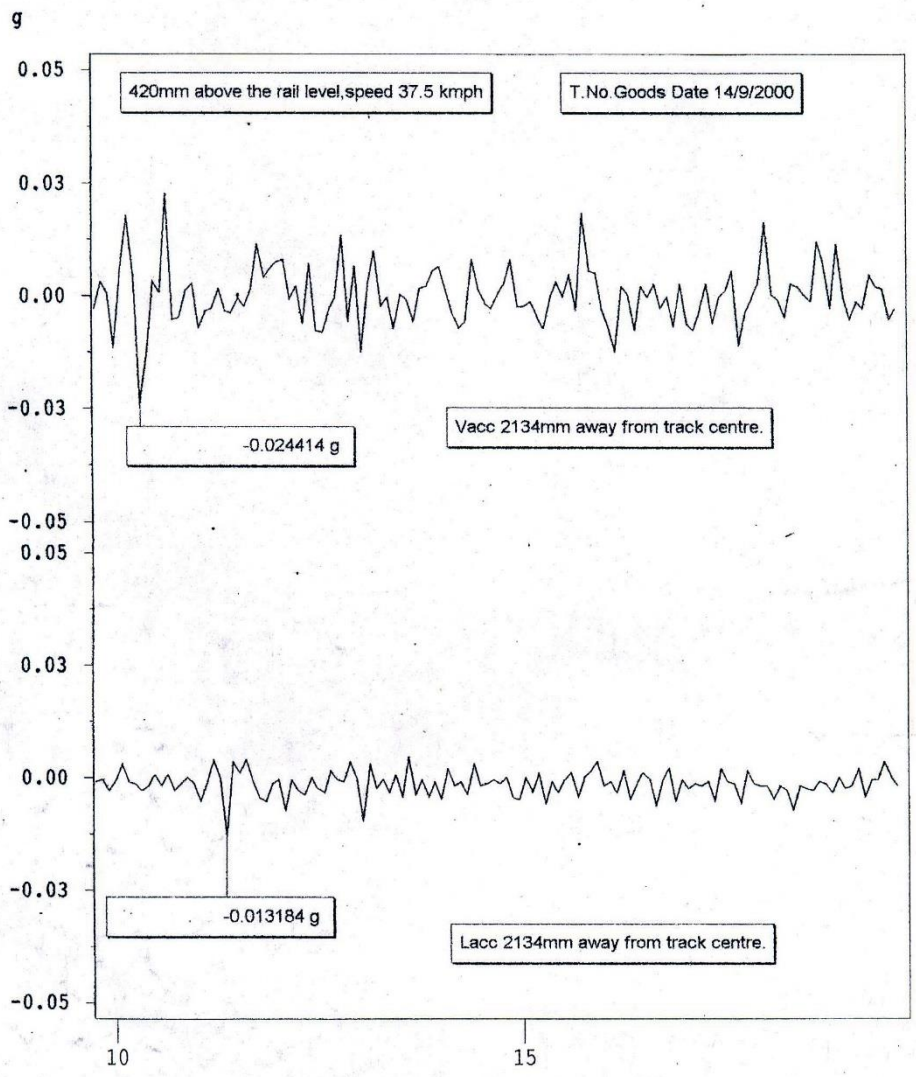
GWL--JHS,Km 1182/21--1182/23



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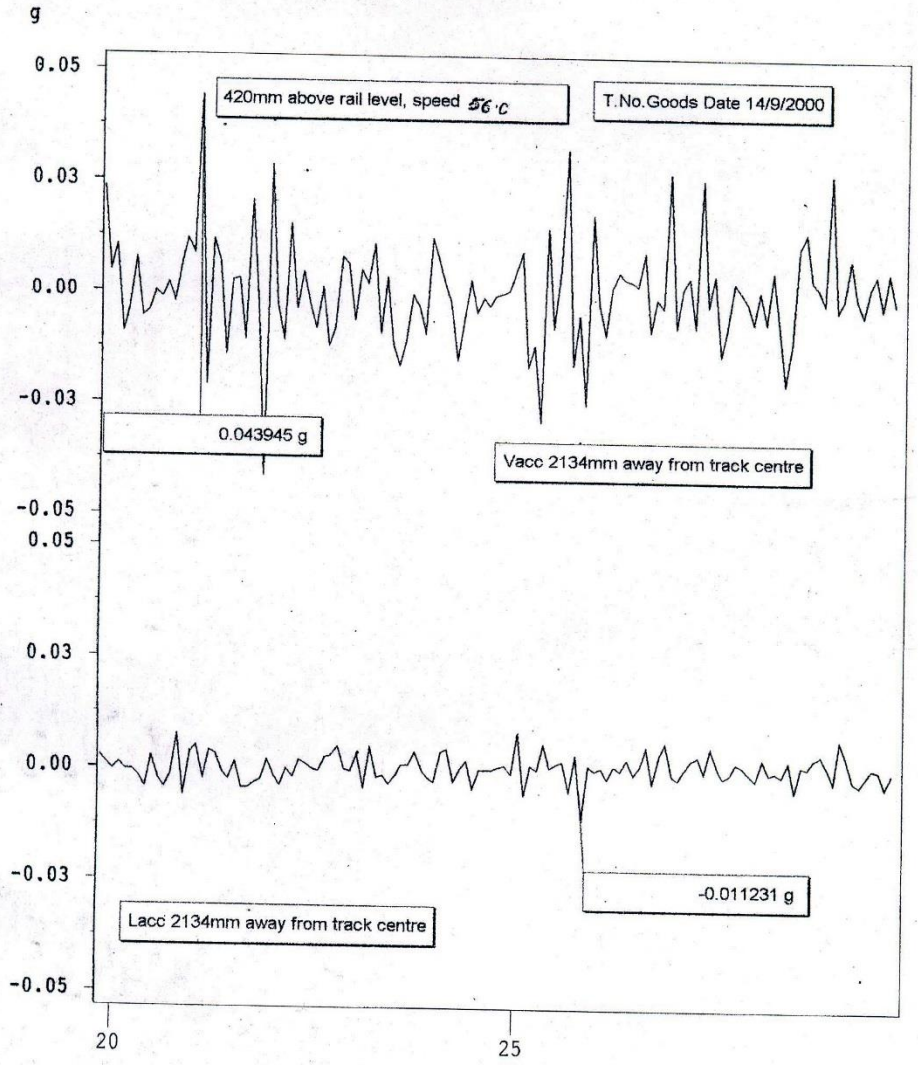
GWL--JHS,Km 1182/21--1182/23



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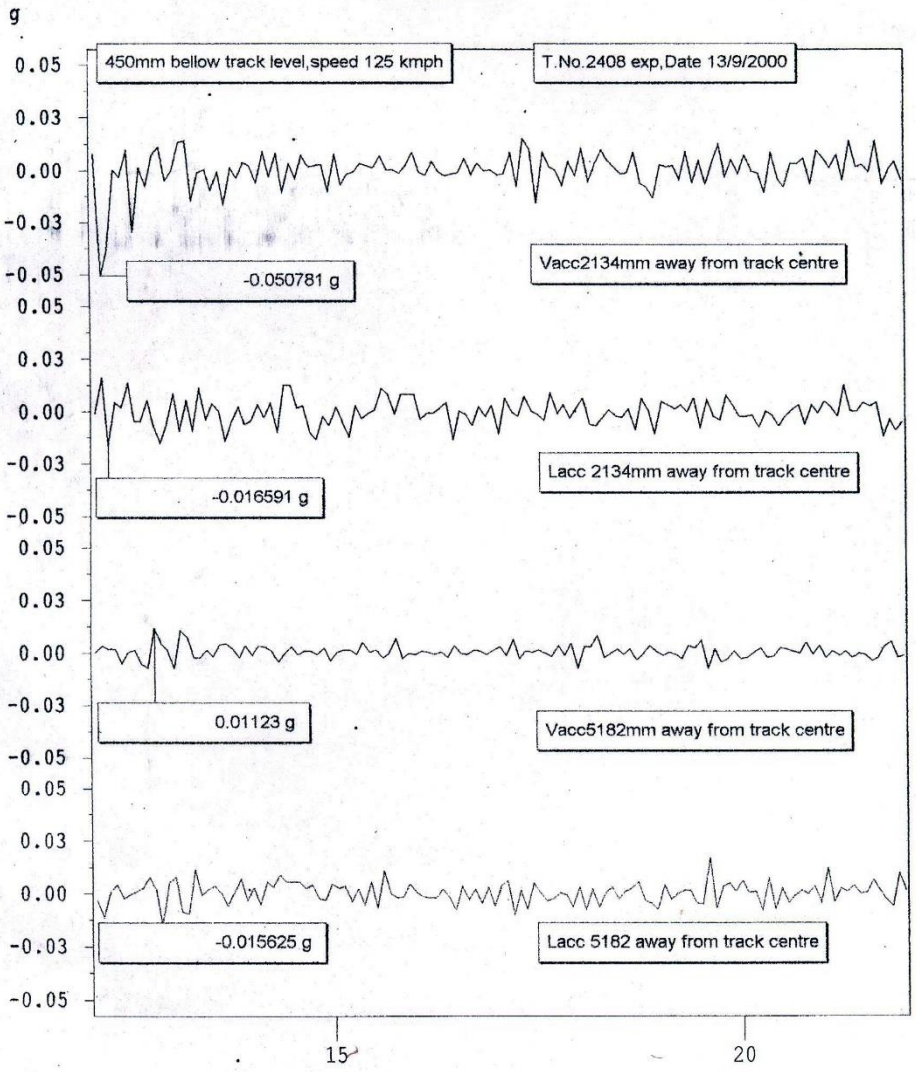
GWL--JHS,Km 1183/1--1183/3



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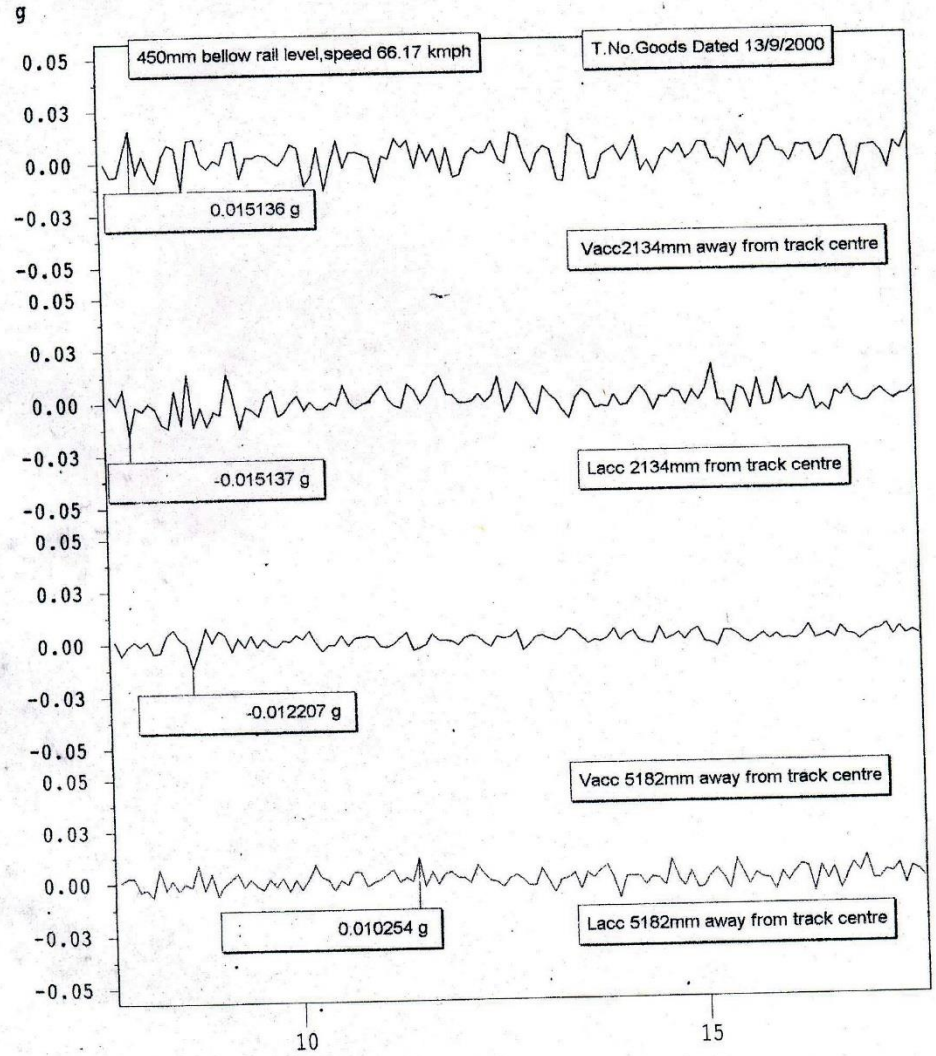

VIBRATION DUE TO RAIL TRAFFIC ALONG TRACK