Effect of Granular Layer Strength and Thickness on Jute Geotextiles Reinforced Rural Road

Souvik Patra and Ashis Kumar Bera

Abstract In the present study, a 3D finite element (FE) analysis has been carried out to study the stress and strain response of Jute Geotextiles (JGT) reinforced rural road by static analysis. In the rural road, JGT has been placed in between top granular layer and subgrade soil with a thin layer of sand above and below of JGT as Sand-JGT-Sand (SJS) reinforcement. SJS reinforced rural road has been modelled and analysed by using the commercial FE software package ABAQUS 6.12. Two types of reinforced rural road section have been developed to simulate the effect of degradation of JGT. Nonlinear behaviour of the road materials has been taken into account for top granular layer, sand and for subgrade soil, JGT has been discretized using membrane element. Results of FE analysis indicate a significant improvement in the service life of SJS reinforced rural road section, before and after degradation of JGT over unreinforced rural road section. Only a small fraction of the tensile strength of JGT has been mobilized in SJS reinforced rural road sections. Maximum percentage utilization of JGT tensile strength has been found as 4.76 and 2.38% for thin and thick top granular layer, respectively.

Keywords FE analysis · Rural road · Jute geotextiles · Service life · Tensile strength

1 Introduction

Construction of pavement on soft subgrade foundation by use of geotextiles is quite common practice today. Recent concerns on environmental awareness also increase the use of natural geotextiles in place of manmade synthetic geotextiles. The main

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differences between these two types of geotextiles are that natural geotextile poses low strength and degrades with time. Recent studies also notified that the degradation does not affect the use of natural geotextile, especially in pavement foundation. Incomparative view of cost, natural geotextiles such as Jute, Coir are cheaper than the manmade synthetic geotextiles. Ramaswami and Aziz (1989) showed that JGT is an effective solution to strengthen the road subgrade especially in low volume roads and on haul roads. In India, low volume roads which carries a design traffic of 10,000–1,00,000 for design period of 10 years also known as Rural roads (IRC SP 72: 2015). The purpose of the rural road is to connect the rural area for economic and social uplift and to provide an all-weather access. Further research work on the application of JGT by Basu et al. (2009) shows the effectiveness of JGT in road application. Khan et al. (2014) carried out extensive field investigation on JGT reinforced rural road in Bangladesh and reported that JGT can provide the beneficial effect like other synthetic geotextiles.

In the present study, an attempt has been made to study the effect of strength and thickness of the top granular layer on the extension of the service life for JGT reinforced rural road system. In the present paper, an attempt has been also made to study the utilization of strength of JGT in the rural road system. Critical pavement responses such as vertical compressive subgrade strain developed at the subgrade soil layer, tensile stress and tensile strain developed at JGT has been observed. In the present analysis, the extension in the service life of rural road due to JGT has described in terms of traffic benefit ratio (TBR).

2 Plan for FE Analysis

To conduct a parametric study and to consider the effect of degradation of JGT in the present work, four types of rural road sections have been considered. These rural road sections are unreinforced rural road (UR), JGT reinforced rural road section before degradation (RJ) and JGT reinforced rural road section after degradation (DJ). Detail of the rural road sections has been presented later. In the present FE analysis in each model series, the strength and thickness of top granular layer have been varied to study the influence of granular layer strength and thickness on the stress and strain values of the rural road sections considered in the present study. The thickness of the top granular layer (h) has been taken as 0.15 and 0.4 m. The strength condition of the top granular layer has been varied as a weak and a strong granular layer based on the California bearing ratio (CBR) of the top granular layer (CBR_{GL}). In weak granular layer, it has been assumed that the layer is made of granular sub-base material (CBR_{GL} = 20%) and in case of the strong granular layer, it has been considered that the layer is made of gravel base material (CBR_{GL} = 80%) (IRC SP 72: 2015). Two types of subgrade soil condition based on subgrade CBR (CBR_{SG}) has been taken as very poor (CBR_{SG} = 2.0%) to fair (CBR_{SG} = 5%) to check the effect of road foundation on the compressive strain values over subgrade soil of JGT reinforced rural road and on the utilization of JGT strength in the rural road. Detail plan for the present FE analysis has been presented in the Table 1.

Table 1 Plan for FE analysis

Model series	Reinforcement type	Model name	*h* (m)
UR	–	UR 150	0.15
	–	UR 400	0.4
RJ	JGT	RJ 150	0.15
	JGT	RJ 400	0.4
DJ	Degraded JGT	DJ 150	0.15
	Degraded JGT	DJ 400	0.4

3 Rural Road Sections

Generally, rural roads are comprised of subgrade soil and the top granular layer above it with or without thin bituminous surface coating (IRC: SP: 20 2002). In rural roads, bituminous surface coating acts as a non-structural layer and hence neglected in the present study. In the present investigation, the rural road has been considered as an unpaved road system.

3.1 Unreinforced Rural Road Section (UR)

In the present investigation, the unreinforced rural road sections have been considered as an unpaved road system with subgrade soil and top granular fill layer above it. In general, rural roads are single lane road comprises of 3.75 m carriageway and shoulders on both sides of the carriageway. In this series (UR) of the model, CBR_{SG} has been kept at 2.0 and 5.0%.

3.2 Rural Road Section Reinforced with JGT (RJ)

This model series contains the SJS reinforced rural road system before degradation of JGT and named as RJ. In this type of model, a unit of JGT with thin sand layers (25 mm thick) on each side of it has been placed as a Sand-JGT-Sand (SJS) reinforcement layer in between subgrade soil and top granular layer. Presence of sand layers on both side of JGT (SJS unit) also enhances the durability and increase the puncture resistance (Midha et al. 2017). In this series of the model, CBR_{SG} has been kept as 2.0 and 5% as in case of UR sections. Figure 1 shows a general configuration of an SJS reinforced rural road before degradation of JGT.

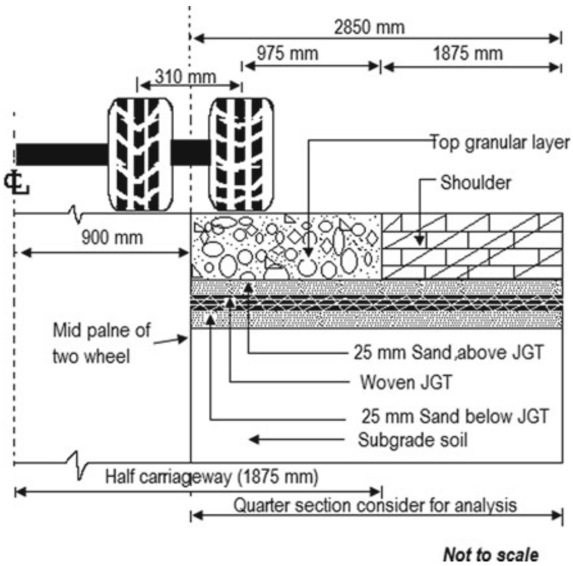

Fig. 1 Schematic sketch of general configuration of an SJS reinforced rural road and area considered for analysis

3.3 Rural Road Section Reinforced with Degraded JGT (DJ)

These types of model series describe the condition of SJS reinforcement in the rural road after degradation of JGT and called in the DJ series. This condition has been accomplished by considering an increased CBR_{SG} and a sand layer of 50 mm without JGT in between top granular fill layer and subgrade soil. Usually, untreated JGT takes about one year for 50% degradation (Saha et al. 2012). In the present analysis, it has been assumed that in one-year subgrade strength has been increased about 1.25 times of its initial CBR_{SG} (Patra and Bera 2017). The subgrade CBR value for degraded reinforced rural road sections is enhanced by 1.25 times, respect to the subgrade CBR values of UR and RJ series of rural road section, i.e. CBR_{SG} of 2.5 and 6.25%.

4 FE Response Model

Development of a suitable FE response model requires to define the soil behaviour in the form of a material constitutive relationship, and it is also a need to simplify the geometry and boundary conditions of the SJS reinforced and unreinforced rural road without compromising the reliability of the output results. A detail description of the consideration of the present FE response model developed in ABAQUS environment has been presented.

4.1 Load and Geometry

In the present paper, the geometry of the unreinforced and SJS reinforced rural road system has been considered as a 3D problem (Cho et al. 1996). In the present investigation, only quarter of the pavement section has been considered to take advantage of the symmetry. It is vital to select a proper domain size for the FE analysis which will provide the most precise response of the rural road structure and the computational cost should be manageable. The size of the FE model for rural road section has been taken as 2.85 m in width (*X*-direction), 3 m along the length (*Y*-direction) and a subgrade depth of 3 m. The depth of the subgrade soil layer has been considered based on a sensitivity analysis carried out by observing the change in compressive strain at the top of subgrade soil with the change in depth of subgrade soil layer. In the present 3D FE modelling of rural road section, the load contact area has been assumed as an equivalent rectangular contact area with a standard axle load of 80 kN (8160 kg or 18 kips) and for a wheel load of 20 kN. In the present paper, a uniformly distributed tyre contact pressure (P_c) of 550 kPa has been considered (Perkins et al. 2012). In the present study, the dimension of the tyre contact area of a wheel load of 20 kN has been taken as 225 mm in length and 160 mm in breadth which involves an area of 36,000 mm^2.

4.2 Materials

Selection of material models to simulate the pavement layers behaviour plays an important role on the results of FE analysis. ABAQUS provides the flexibility to adopt different material models such as linear elastic, porous elastic, plastic, visco-elastic, etc. Generally, in the unpaved road system, the pavement layers pose nonlinear material behaviour. In the present work subgrade soil, top granular layer and sand have been modelled as an elasto-plastic material. JGT and shoulder have been considered as a linear elastic material. In the present analysis, the elastic modulus of woven JGT has been determined based wide width tensile strength test in accordance with ASTM D4595 (2001) in the Geotechnical Engineering Laboratory at IIEST, Shibpur. The elastic modulus has been taken as secant modulus obtain at peak. Perkins et al. (2012) reported to consider a Poisson's ratio (v) of 0.25 for geotextiles. In the present study, Poisson's ratio of JGT has been taken as 0.25. Material parameters used for sand have been determined based on static triaxial compression test carried out in the Geotechnical Engineering Laboratory at IIEST, Shibpur. The elastic modulus of sand has been taken as the initial tangent modulus at low confining pressure. Details of the materials parameter considered in the present FE analysis have been presented in Table 2.

In the present FE modelling, plasticity has been defined using Drucker-Prager plasticity model (DP). Drucker-Prager failure surface is defined by the following Eq. (1)

Table 2 Materials parameters for present FE analysis

Pavement layer	CBR (%)	Linear elasticity		Plasticity	
		M_R (MPa)	ν	β (°)	d (kPa)
Weak GL	20	88.43	0.35	50.19	20.78
Strong GL	80	134.03	0.35	58.56	29.25
Shoulder	–	75	0.4	–	–
Sand	–	48.88	0.35	57.57	1.97
JGT	–	100	0.25	–	–
Subgrade (Poor)	2	20	0.4	16.27	155.77
Subgrade (Fair)	5	50	0.4	37.67	397.73

GL Granular Layer

$$F_S = q - p\tan\beta - d = 0 \tag{1}$$

where 'p' is the mean normal stress, 'q' is the principal stress difference, 'β' is the material's angle of friction, i.e., the angle of the yield surface in p–q stress space and 'd' is its cohesion, i.e., the intercept at the ordinate by the yield surface in p–q stress space. In the present study, the resilient modulus of the top granular soil layer ($M_{R-\mathrm{GL}}$) has been determined by using Eq. (2) which was adopted by Giroud and Han (2004).

$$M_{R-\mathrm{GL}} = 30\,\mathrm{MPa} \times \mathrm{CBR}_{\mathrm{GL}}^{0.3} \tag{2}$$

Similarly, the resilient modulus of subgrade soil ($M_{R-\mathrm{SG}}$) has been determined based on its soaked CBR value using Eq. (3) (IRC: 37 2012).

$$M_{R-\mathrm{SG}}(\mathrm{MPa}) = 10 \times \mathrm{CBR}_{\mathrm{SG}}[\mathrm{for\,CBR}_{\mathrm{SG}} \le 5\%] \tag{3}$$

In the present analysis, undrained cohesion (c_{u}) of the subgrade soil layer has been calculated using Eq. (4), proposed by Giroud and Han (2004).

$$c_{\mathrm{u}}(\mathrm{kPa}) = 30 \times \mathrm{CBR}_{\mathrm{SG}}(\%) \tag{4}$$

4.3 Boundary Conditions and Analysis

Selection of proper boundary condition has a significant effect on the responses obtained from FE analysis. In the present analysis, the bottom nodes of the model have been considered as fixed support. The vertical sides at the mid of two wheels and mid-plane of a single wheel have been assumed as X-symmetric plane and Y-symmetric plane, respectively. Along the line of symmetry horizontal displacements are restricted and the nodes are allowed to move freely in the Z-direction. The vertical faces away from the wheels have been defined by roller support.

In the present analysis, all the connecting interfaces of pavement layers have been simulated using tie constraints followed by the selection of master and slave surfaces (Hibbitt et al. 2012). A similar type of interaction between pavement layers has been adopted successfully earlier by Abu-Farsakh et al. (2014). In the present paper, the analysis procedure has been considered as static analysis.

4.4 Discretization

Meshing criteria is one of the most important considerations in FE analysis. The results of the analysis can change significantly based on element type, shape and size. As the loading on the pavement surface is localized, finer mesh near the loading area and coarser mesh away from the load area has been adopted. In the present study, C3D8R, an 8-node linear brick element with reduced integration scheme, has been used to discretize the top granular layer, shoulder, sand and subgrade soil layer. Previous researchers, Taherkhani and Jalali (2017), have also reported that C3D8R is a stable and a suitable element for FE analysis on pavement system. Kuo and Chou (2004) simulate the geogrid reinforcement by the use of a layer of membrane element. In the present analysis, JGT has been considered as a membrane type material and JGT has been discretized using 4-noded membrane element (M3D4R) with reduced integration scheme from ABAQUS element library. In this present study, the thickness of the membrane element has been taken as 1.46 mm. In the present FE modelling, an element size of 0.04 mm × 0.04 mm × 0.04 mm has been used at the loading area, based on the mesh convergence study. A similar discretizing technique has been adopted earlier in Patra and Bera (2016).

4.5 Validation of the Present FE Model

Before proceeding to the further analysis to study the effect of strength and thickness of the top granular layer on SJS reinforced rural road, it is necessary to validate the model with existing acceptable results. For this purpose, results obtained from FE model developed in the present study have been compared with results presented in Gupta et al. (2015). The validation has been carried out in terms of vertical compressive subgrade strain at the top of subgrade soil layer. For this purpose, UR400 section has been taken and a uniform tyre pressure of 0.56 MPa has been applied on rectangular tyre contact areas. Two type of tyre contact area has been consider as Imprint-1, having dimensions of 225 mm × 160 mm according to the present study, and Imprint-II having a dimension of 200 mm × 180 mm as per Gupta et al. (2015). Linear elastic and nonlinear material parameters have been taken from Gupta et al. (2015). From the analysis, it has been seen that the results obtained in the present study are close to Gupta et al. (2015). The difference between the strain values is about 8.94 and 6.16% for tyre Imprint-I and imprint-II. Hence, the developed FE model of the rural road section in ABAQUS can be expected acceptable to conduct an FE analysis of unreinforced and SJS reinforced rural road sections.

5 Results and Discussions

In the present FE analysis, a detail investigation has been carried out on vertical compressive subgrade strain (ε_z) at the top of subgrade soil and on development of tensile stress and tensile strain in JGT. In the present study, the effect of strength of top granular layer has been described in terms of modulus ratio (R_M). Modulus ratio has been determined as in Eq. 5 (Giroud and Han 2004).

$$\text{Modulus ratio}(R_\mathrm{M}) = \frac{M_{R-\mathrm{GL}}}{M_{R-\mathrm{SG}}} \tag{5}$$

The beneficial effect of SJS reinforced rural road has been evaluated in terms of TBR and presented in Fig. 2. Figure 3a, b present the percentage (%) of JGT tensile strength utilized with modulus ratio for the top granular layer thickness of 0.15 and 0.4 m, respectively. Table 3 shows the TBR values obtained for both the SJS reinforced section before and after degradation of JGT. In Table 4, tensile stress (σ_1) and tensile strain (ε_1) developed in JGT for the SJS reinforced section before degradation of JGT has been presented. Based on the results obtained from the present FE analysis, a discussion has been made on the following points.

- Vertical compressive subgrade strain (ε_z) and TBR.
- Strength mobilization in JGT.

5.1 *Vertical Compressive Subgrade Strain (ε_z) and TBR*

Vertical compressive subgrade strain (ε_z) is the most important parameter in design of flexible pavement system with thin surface coating. Various pavement design authority such as Asphalt Institute, Indian Road Congress (IRC) also relate this parameters to compute the allowable load repetitions of a pavement structure for a particular limiting rut depth. Qiu et al. (2000) suggested a limiting rut value of 25 mm for low volume roads. In the present study, failure of a rural road has been taken as a limiting rut of 25 mm. Gupta et al. (2014) proposed a mechanistic design criteria for rut depth of 25 mm in case of unreinforced low volume roads, considering nonlinearity in both top granular and in subgrade soil, as in the Eq. (6). Here, $N_{25\,\mathrm{mm}}$ is the number of load repetitions which causes a surface rut of 25 mm. Equation (6) can be modified to obtain allowable load repetitions for a limiting rut

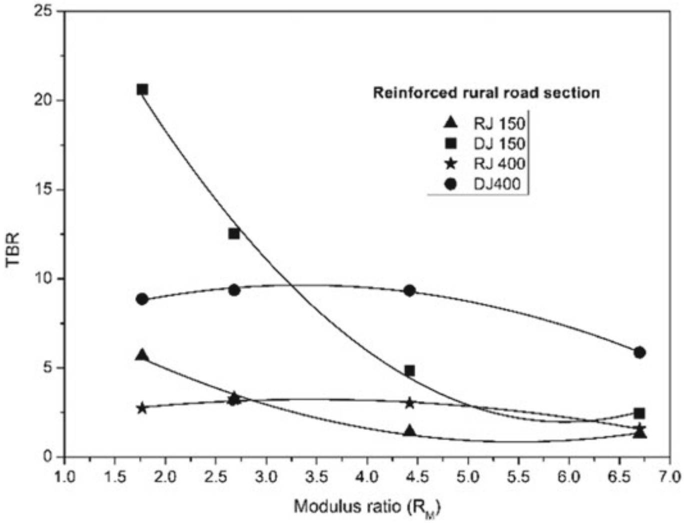

Fig. 2 Plots between TBR (TBR_{RJ} and TBR_{DJ}) and modulus ratio of the rural road structure

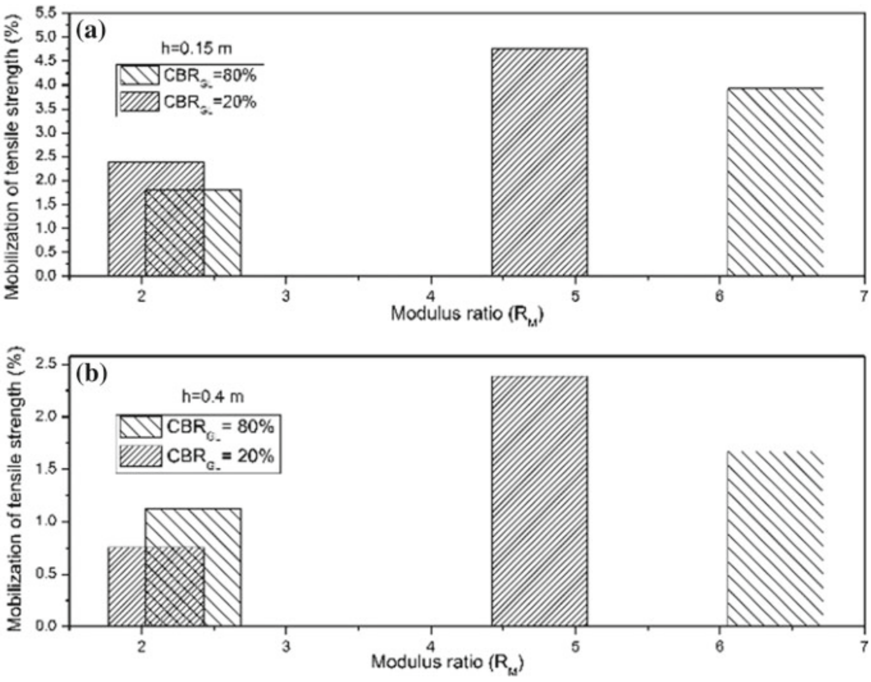

Fig. 3 Percentage of JGT tensile strength mobilized with modulus ratio for **a** top granular layer thickness of 0.15 m and for **b** top granular layer thickness of 0.4 m

Table 3 TBR_{RJ} and TBR_{DJ} values obtained for SJS reinforced rural road sections

CBR_{GL} (%)	CBR_{SG} (%)	TBR_{RJ}		TBR_{DJ}	
		h = 0.15 m	h = 0.4 m	h = 0.15 m	h = 0.4 m
20	2	1.41	3.03	4.82	9.34
20	5	5.68	2.74	20.61	8.87
80	2	1.32	1.58	2.46	5.87
80	5	3.25	3.24	12.53	9.36

Table 4 Tensile stress and strain developed in the JGT

CBR_{GL} (%)	CBR_{SG} (%)	Thickness of granular layer (h)			
		0.15 m		0.4 m	
		σ_1 (kPa)	ε_1 (%)	σ_1 (kPa)	ε_1 (%)
20	2	562.82	0.442	282.46	0.223
20	5	281.40	0.216	89.36	0.107
80	2	464.52	0.375	197.85	0.157
80	5	213.93	0.170	133.56	0.071

depth of 25 mm as in Eq. (7). Equation (7) has been applied for all the rural road sections considered in the present study.

$$\varepsilon_z = 0.0058 \times N_{25\,\mathrm{mm}}{}^{-0.171} \tag{6}$$

$$N_{25\,\mathrm{mm}} = 8.329 \times 10^{-14} \times \left(\frac{1}{\varepsilon_z}\right)^{5.848} \tag{7}$$

In the present study, the reduction in 'ε_z' due to SJS reinforcement at the top subgrade soil has been presented in terms of TBR. Chandra et al. (2008) determined TBR with the help of vertical compressive subgrade strain 'ε_z'. In the present study TBR, for both the SJS reinforced rural road sections, before and after degradation of JGT has been determined using Eq. (8) and using Eq. (9), respectively.

$$\mathrm{TBR_{RJ}} = \left(\frac{\varepsilon_{z-\mathrm{RJ}}}{\varepsilon_{z-\mathrm{UR}}}\right)^{-5.848} \tag{8}$$

$$\mathrm{TBR_{DJ}} = \left(\frac{\varepsilon_{z-\mathrm{DJ}}}{\varepsilon_{z-\mathrm{UR}}}\right)^{-5.848} \tag{9}$$

where TBR_{RJ}, and TBR_{DJ} are the TBR values for the SJS reinforced rural road section before degradation of JGT and the TBR values for the reinforced section after degradation of JGT, respectively. '$\varepsilon_{z-\mathrm{UR}}$', '$\varepsilon_{z-\mathrm{RJ}}$', and '$\varepsilon_{z-\mathrm{DJ}}$' are the '$\varepsilon_z$' measured at the top of subgrade soil for the unreinforced, SJS reinforced, and reinforced section after degradation of JGT, respectively. From Fig. 2, it has been seen that as the modulus ratio between the top granular layer and subgrade soil is increasing and the TBR values are decreasing. Figure 2 also revealed that the nature of decreasing of TBR values with increase in modulus ratio is influenced by the thickness of the top granular soil. It has been also found that for lower thickness of top granular layer (0.15 m), there is a continuous decrease in TBR values with increase in modulus ratio, i.e., as the subgrade strength is decreasing lower, TBR_{RJ} and TBR_{DJ} values have been obtained depending on the strength of the top granular layer.

Whereas in case of a rural road section with a higher top granular layer thickness (0.4 m) shows an optimum value of TBR_{RJ} and TBR_{DJ} values are higher for a particular 'R_M'. This notified that the maximum benefit due to SJS reinforcement in the rural road can be achieved for a particular range of modulus ratio. In the present study, from the Fig. 2, for 0.4 m of the top granular layer, it can be said that maximum values of TBR_{RJ} and TBR_{DJ} will be achieved at a modulus ratio around 3.75 and 4.25, respectively. From Table 3, it has been observed that for poor subgrade soil condition, a decrease in top granular layer strength leads to increase both TBR_{RJ} and TBR_{DJ}. A decrease in top granular layer strength from CBR_{GL} of 80–20% leads to increase the TBR_{RJ} and TBR_{DJ} values in the range of 1.07–1.91 times and 1.93–2.38 times, respectively. In case of fair subgrade soil (CBR_{SG} = 5%), a decrease in top granular layer strength leads to increase the TBR_{RJ} and TBR_{DJ} values for the lower thickness of top granular layer (0.15 m). Whereas in the case of the higher thickness of the top granular layer (0.4 m), a decrease in top granular layer strength leads to decrease the TBR_{RJ} and TBR_{DJ} values with strong subgrade soil foundation. The reason is that with higher thickness and strong subgrade soil foundation makes the rural road structure less dependent on SJS reinforcement before and after degradation of JGT. Hufenus et al. (2006) also reported that the inclusion of reinforcement in unpaved road system is effective for $CBR_{SG} \leq 3\%$ and when $h \leq 0.5$ m. In the present study, it has been seen that TBR_{DJ} values are higher than the TBR_{RJ} values which imply that the increment in subgrade strength leads to a higher benefit. It is due to that the vertical compressive subgrade strain is also related to the bearing capacity of the subgrade soil. In the present study, it has been also noticed that for the soft subgrade soil condition, an increase in top granular layer thickness from 0.15 to 0.4 m results in an increase in TBR_{RJ} values for weak and strong top granular layer of 2.16 times and 1.20 times, respectively. Similarly, TBR_{DJ} values have been increased 1.59 times and 1.96 for weak and strong top granular layer, respectively. In case of strong subgrade soil, it has been observed that an increase in top granular layer thickness leads to decrease both TBR_{RJ} and TBR_{DJ} values.

5.2 Strength Mobilization in JGT

In the present mechanistic analysis, an attempt has been also made to study the utilization of tensile strength of JGT in SJS reinforcement. For this purpose, maximum stresses (σ_x, σ_y and τ_{xy}) developed in the JGT under the wheel load has measured for the SJS reinforced rural road section before degradation of JGT. Similar strain measurement has been performed in the JGT under the tyre pressure of 0.55 MPa. The major principle stress (σ_1) developed in the JGT, which corresponds to the tension of the geotextile has been calculated using Eq. (10) (Bhandari and Han 2010).

$$\sigma_1 = \frac{(\sigma_x + \sigma_y)}{2} + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} \tag{10}$$

The tension developed in the JGT under the wheel loading has been calculated using Eq. (11)

$$T_{\mathrm{MJ}} = \sigma_1 \times t_{\mathrm{J}} \tag{11}$$

where, 'T_{MJ}' in kN, is the tension mobilized at JGT in SJS reinforcement and 't_{J}' (m) is the thickness of JGT.

Figure 3a, b shows the mobilization of the tensile strength of JGT used in the present study. Table 4 presents the values of principal stress and strain, i.e., tensile stress and tensile strain developed in JGT for SJS reinforced section (before degradation of JGT) considered in the present study. From Table 4, it has been seen that the tensile strain developed in the JGT is in the range of 0.167–0.442% and 0.071–0.375% for weak and strong granular layers, respectively. Figure 3 presents the mobilization of tensile strength (%) in JGT at different modulus ratio for weak and strong granular layers. From Fig. 3, it has been observed that in case soft subgrade soil ($\mathrm{CBR_{SG}}$ = 2%), a decrease in top granular layer strength from $\mathrm{CBR_{GL}}$ of 80–20% leads to increase in strength mobilization of JGT from 3.93 to 4.76% and 1.67 to 2.39% for thin (0.15 m) and thick (0.4 m) granular layer, respectively. In case strong subgrade soil ($\mathrm{CBR_{SG}}$ = 5%), an increase in top granular layer thickness from 0.15 to 0.4 m results in a reduction in strength utilization of JGT from 1.81 to 1.13%. From Fig. 3, it has been also found that a reduction in top granular layer thickness from 0.4 to 0.15 m leads to an increase in strength utilization of JGT is in the range of 1.60 times to 3.15 times. Similarly, an increase in strength of top granular layer from $\mathrm{CBR_{GL}}$ of 20–80% results in a reduction in tensile strength mobilization of JGT which is in the range of 0.67 times to 1.42 times.

6 Conclusion

In the present paper, a series of FE simulations have been carried out to investigate the benefits of SJS reinforcement in rural roads. Efforts have been also made to study the influence of top granular layer strength and thickness in the extension of service life of the rural road section and to determine the strength utilization in SJS reinforcement. Based on the present FE modelling, results of analysis and based on the discussion made earlier, following conclusions have been drawn:

- For poor subgrade soil condition, a decrease in top granular layer strength from CBR_{GL} of 80–20% leads to increase both the TBR_{RJ} and TBR_{DJ} values.
- In case of soft subgrade soil foundation, an increase in top granular layer thickness, the values of TBR_{RJ} and TBR_{DJ} are increasing for both weak and strong top granular layer, respectively.
- TBR_{RJ} and TBR_{DJ} values have found to be falling with an increase in top granular layer thickness for strong subgrade soil (CBR_{SG} = 5%).
- The TBR_{RJ} and TBR_{DJ} values are found within the range of 1.32–5.68 and in the range of 2.46–20.61, respectively, under study.
- A small fraction of the tensile strength of JGT has been mobilized in SJS reinforced rural road sections. Maximum percentage utilization of JGT tensile strength has been found as 4.76 and 2.38% for thin (0.15 m) and thick (0.4 m) top granular layer.

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