Course Syllabus and Content for Masters Degree

FMPE 501: Soil Dynamics in Tillage and Traction 2+1

Objectives:

To have an understanding of the principles of soil mechanics as applied to interaction oftillage tools and traction devices with soil in terms of soil forces and deformation during for soil cutting and generation of traction.

Unit-I

Characterization of state of stress in a point: Derivation, representation by Mohr's Circle. Coulomb's law of friction and cohesion. Measurement of soil resistance properties: Direct shear box, torsion shear apparatus, tri-axial apparatus. Soil behaviour considerations: Soil water pressure and movement. Critical state soil mechanics: Soil stress-strain behaviour, shear rate effects.

Unit-II

Mechanics of tillage too and geometry of soil tool system , design parameters and performance of tillage tools, Soil cutting forces: The universal earthmoving equation, two dimensional cases, smooth vertical blade, smooth and rough raked blades in cohesive soil, unconstrained tool to soil adhesion. The shape of failure surfaces. Hettiaratchi's calculations, effect of soil weight. Soil cutting force by method of trial wedges.

Unit-III

Extension of theory to three dimension: Hettiaratchi, Reece-Godwin and Spoor. Three dimensional wedges: McKyes and Ali, Grisso models. Dynamic effect: Inertial forces, change in soil strength. Concept of critical depth. Complex tool shapes: Curved tools-shank and foot tools-mould board plough. Soil Loosening and manipulation: Measurement of soil loosening and its efficiency. Draft force efficiency: Loosening and pulverization efficiency. Soil mixing and inversion: Soil properties, tool shape, tool speed and tool spacing.

Unit-IV

Traction devices: Tyres, type, size, selection mechanics of traction devices. Maximum traction force: Soil deformation and slip, estimation of contact areas. Sinkage in soil: Rolling resistance, Bekker's formulae, McKyes formulae. Soil compaction by agricultural vehiclesand machines.

Practical:

Measurements of soil shear strength by in-situ shear box apparatus and soil friction by friction plate. Measuring cone penetrometer resistance and working out tractive coefficientsfor tyres. Measurement of in-situ shear strength of soil by torsional vane shear apparatus. Solving problems on stress in soil. Solving problems on soil properties. Solving problems of tool forces. Problems on tillage tool forces, wheel slippage, tyre deflection, design and performance of traction devices.

Course Outcome:

The student will be able to understand the principles that govern manipulation of soil bytillage tools. The student will be able to apply the principles of soil mechanics to theoretically calculate the forces on tillage tools during soil cutting and forces generated by tractor wheels.

Teaching Schedule

S. No.	Topic	No of Lectures
1.	Characterization of state of representation by Mohr's Circle. Stress in A point: Derivation,	2

2.	Coulomb's law of friction and cohesion.	1
3	Measurement of soil resistance properties: Direct shear box, torsionshear apparatus, tri-axial apparatus.	2
4	Soil behaviour considerations: Soil water pressure and movement.	1
5	Critical state soil mechanics: Soil stress-strain behaviour, shear rateeffects	2
6	Mechanics of tillage too and geometry of soil tool system , design parameters and performance of tillage tools. Soil cutting forces: The universal earthmoving equation, two dimensional cases, smooth vertical blade, smooth and rough raked blades in cohesive soil, unconstrained tool to soil adhesion.	3
7	The shape of failure surfaces.	2
8	Hettiaratchi's calculations, effect of soil weight.	2
9	Soil cutting force by method of trial wedges.	2
10	Extension of theory to three dimensions: Hettiaratchi, Reece-Godwin and Spoor.	2
11	Three dimensional wedges: McKyes and Ali, Grisso models. Dynamic effect: Inertial forces, change in soil strength.	2
12	Concept of critical depth.	1
13	Complex tool shapes: Curved tools-shank and foot tools-mould board plough.	1
14	Soil Loosening and manipulation: Measurement of soil looseningand its efficiency.	1
15	Draft force efficiency: Loosening and pulverization efficiency.	1
16	Soil mixing and inversion: Soil properties, tool shape, tool speedand tool spacing.	2
17	Traction devices: Tyres, type, size, selection mechanics of tractiondevices.	1
18	Maximum traction force: Soil deformation and slip, estimation ofcontact areas.	1
19	Sinkage in soil: Rolling resistance, Bekker's formulae, McKyes formulae.	2
20	Soil compaction by agricultural vehicles and machines.	1
	Total	**32**

List of Practicals

Sr. No.	**Topic**	**No of practicals**
1.	Measurements of soil shear strength by in-situ shear box apparatus and soil friction by friction plate.	3

2.	Measuring cone penetrometer resistance and working out tractive coefficients for tyres.	2
3.	Measurement of in-situ shear strength of soil by torsional vane shear apparatus.	1
4.	Solving problems on stress in soil.	2
5.	Solving problems on soil properties.	2
6.	Solving problems of tillage tool forces.	1
7.	Problems on wheel slippage and tyre deflection.	3
8.	Problems on design and performance of traction devices.	1
9.	Practical examination	1
	Total	**16**

Suggested Reading:

1. McKyes E 2016. Soil Cutting and Tillage: Vol 7. *Developments in Agricultural Engineering* Elsevier R Science Publisher SBV.
2. Koolen, A J and Kuipers H 1983. *Agricultural Soil Mechanics. Springer-Verlag* ISBN 13:978-3-642-69012-9.
3. Gill W R and Van den Berg G E 1968. *Soil Dynamics in Tillage and Traction*. Handbook 316, Agricultural Research Service, US Department of Agriculture, Washington DC, 1968
4. John B L, Paul K T, David W S and Makoto H 2012. *Tractors and their Power Units*. 4th Edition. Springer Science & Business Media, ISBN: 81-239-0501-7, ASAE ISBN: 0-929355-72-5.
5. McKYES E 1989, *Agricultural Engineering Soil Mechanics*, Elsevier science publishers B. V., P.O. Box 211, 1000 AE Amsterdam, the Netherlands.
6. Willium J Chancellor.1995. *Advances in Soil Dynamics*. Vol. 1.ASAE, First Ed
7. Sinekov G.N. 1965. *Design of Soil Tillage Machines*. INSDOC, New Delhi