Kandula Srinivasa Reddy Memorial College of Engineering (Autonomous)

Kadapa-516003. AP

(Approved by AICTE, Affiliated to JNTUA, Ananthapuramu, Accredited by NAAC)

(An ISO 9001-2008 Certified Institution)

Department of Civil Engineering

Certification Course

on

Liquefaction analysis of soil using FEA Media & IS1893-2015

Course Instructor: Sri. P. Suresh Praveen Kumar, Assistant Professor, CED

Course Coordinator: Sri. Ch. Santhosh Kumar, Assistant Professor, CED

Sri. E. Manoranjitha, Assistant Professor, CED

Date: 17/05/21 to 31/05/21

Lr./KSRMCE/CE/2020-21/

Date: 12-05-2021

From

Sri Ch. Santhosh Kumar and E. Manoranjitha,
Asst. Professor,
Dept. of Civil Engineering,
KSRMCE,
Kadapa.

To

The Principal,
KSRMCE,
Kadapa.

Sub: Permission to Conduct Certificate Course – Reg.

Dear Sir,

The Department of Civil Engineering is planning to offer a certification course on "Liquefaction analysis of soil using FEA Media & IS1893-2015" to B. Tech. students of Civil Engineering. The course will start on 17th May 2021 to 31st May 2021 and the course will run for a total number of 30 hours. In this regard, I am requesting you to accept the proposal to conduct certificate course.

Thanking you

Yours faithfully

(Sri Ch. Santhosh Kumar and E. Manoranjitha)

Permitted
V.S.S. Murthy

Cr./KSRMCE/CE/2020-21/

Date: 14/05/2021

Circular

The Department of Civil Engineering is offering a certification course on "Liquefaction analysis of soil using FEA Media & IS1893-2015". The course will start on 17-05-2021 and the course will run for a total number of 30 hours. In this regard, interested students of Civil Engineering are required to register for the Certification Course. The registration link is given below.

https://docs.google.com/forms/f/g/LJGrys52mZKShnvlGSFSjI24pjWfgxBBNJDGosd32GfNNKDaudoaslT9w/viewform

The Course Coordinator
Sri Ch. Santhosh Kumar and E. Manoranjitha,
Assistant Professor,
Dept. of Civil Engg.-KSRMCE.

V. S. S. Murthy

Principal

PRINCIPAL
K.S.R.M. COLLEGE OF ENGINEERING
KADAPA - 516 003. (A.P.)

Cc to:

The Director, KSRMCE

The HoD-Civil, KSRMCE

IQAC-KSRMCE

K.S.R.M. COLLEGE OF ENGINEERING

(UGC-AUTONOMOUS)

Kadapa, Andhra Pradesh, India– 516 003

LIGHTED TO LIGHTEN **Approved by AICTE, New Delhi & Affiliated to JNTUA, Ananthapuramu.**

An ISO 14001:2004 & 9001: 2015 Certified Institution

Department of Civil Engineering

Registration list of Certification course
on
Liquefaction analysis of soil using FEA Media & IS1893-2015

Sl. No.	Student Roll No.	Student Name	Sec.	Mail ID
1	199Y1A0109	Chennakeshava Dirasantha	A	199Y1A0109@ksrmce.ac.in
2	199Y1A0116	Venkata Sai Janapati	A	199Y1A0116@ksrmce.ac.in
3	199Y1A0122	Nagarathna Kumbhagiri	A	199Y1A0122@ksrmce.ac.in
4	199Y1A0141	Divya Ragi	A	199Y1A0141@ksrmce.ac.in
5	199Y1A0143	Hima Bindu Ravella	A	199Y1A0143@ksrmce.ac.in
6	199Y1A0147	Sudharshan Sandella	A	199Y1A0147@ksrmce.ac.in
7	199Y1A0159	Venkata Sai Pavan Sravanaboina	B	199Y1A0159@ksrmce.ac.in
8	199Y1A0163	Zareena Tasneem Syed	B	199Y1A0163@ksrmce.ac.in
9	199Y1A0167	Chandrasekhar Vadde	B	199Y1A0167@ksrmce.ac.in
10	209Y5A0101	Supraja Amarai	B	209Y5A0101@ksrmce.ac.in
11	209Y5A0102	Mahesh Amruthapuri	B	209Y5A0102@ksrmce.ac.in
12	209Y5A0104	Surendra B	B	209Y5A0104@ksrmce.ac.in
13	209Y5A0105	Chinna Obulesu Bandela	B	209Y5A0105@ksrmce.ac.in
14	209Y5A0106	Sreehari Battena	B	209Y5A0106@ksrmce.ac.in
15	209Y5A0109	Vishnu Vardhan Reddy Bollavaram	B	209Y5A0109@ksrmce.ac.in
16	209Y5A0110	Venkata Harsha Vardhini Boreddy	B	209Y5A0110@ksrmce.ac.in
17	209Y5A0111	Rupesh C	B	209Y5A0111@ksrmce.ac.in
18	209Y5A0112	Upendra Chakali	B	209Y5A0112@ksrmce.ac.in
19	209Y5A0114	Prudhviswar Reddy Chinnapareddy	B	209Y5A0114@ksrmce.ac.in

20	209Y5A0117	Jayadev Doppani	B	209Y5A0117@ksrmce.ac.in
21	209Y5A0118	Surekha Duggireddy	B	209Y5A0118@ksrmce.ac.in
22	209Y5A0120	Harini G	B	209Y5A0120@ksrmce.ac.in
23	209Y5A0123	Veera Chandana Giddaluru	B	209Y5A0123@ksrmce.ac.in
24	209Y5A0124	Geetha Nandini Gorige	B	209Y5A0124@ksrmce.ac.in
25	209Y5A0126	Venkata Sai Prasanna Jandlamaram	B	209Y5A0126@ksrmce.ac.in
26	209Y5A0127	Boya Kondaiah Jeripiti	B	209Y5A0127@ksrmce.ac.in
27	209Y5A0128	Kalinga Jukuru	B	209Y5A0128@ksrmce.ac.in
28	209Y5A0129	Guru Vinod Kaluva	B	209Y5A0129@ksrmce.ac.in
29	209Y5A0132	Jyothi Sujatha Kodivalasa	B	209Y5A0132@ksrmce.ac.in
30	209Y5A0134	Ramakrishna Kondapuram	B	209Y5A0134@ksrmce.ac.in
31	209Y5A0137	Dwarakanath Reddy Levaku	C	209Y5A0137@ksrmce.ac.in
32	209Y5A0139	Venkata Naveen Kumar Maduru	C	209Y5A0139@ksrmce.ac.in
33	209Y5A0141	Venkata Siva Mandem	C	209Y5A0141@ksrmce.ac.in
34	209Y5A0142	Sneha Mandugundu	C	209Y5A0142@ksrmce.ac.in
35	209Y5A0143	Ganesh Matamkari	C	209Y5A0143@ksrmce.ac.in
36	209Y5A0145	Venkata Jagadeeshwar Reddy Mudamala	C	209Y5A0145@ksrmce.ac.in
37	209Y5A0146	Kirankumar Reddy Mudiveti	C	209Y5A0146@ksrmce.ac.in
38	209Y5A0147	Jithendra Reddy Mule	C	209Y5A0147@ksrmce.ac.in
39	209Y5A0148	Hari Krishna Mutta	C	209Y5A0148@ksrmce.ac.in
40	209Y5A0150	Suneel Kumar Nandyala	C	209Y5A0150@ksrmce.ac.in
41	209Y5A0153	Sowjanya Nimmakayala	C	209Y5A0153@ksrmce.ac.in
42	209Y5A0154	Ammeer Basha Pagadala	C	209Y5A0154@ksrmce.ac.in
43	209Y5A0156	Asma Paidepalli	C	209Y5A0156@ksrmce.ac.in
44	209Y5A0157	Ramakumar Palla	C	209Y5A0157@ksrmce.ac.in
45	209Y5A0158	Obula Reddy Pasam	C	209Y5A0158@ksrmce.ac.in
46	209Y5A0159	Ajay Kumar Pesala	C	209Y5A0159@ksrmce.ac.in

47	209Y5A0160	Madhusudhana Peyala	C	209Y5A0160@ksrmce.ac.in
48	209Y5A0161	Lakshmana Pillagowla	C	209Y5A0161@ksrmce.ac.in
49	209Y5A0170	Jaya Simha Santolla	C	209Y5A0170@ksrmce.ac.in
50	209Y5A0174	Sohail Shaik	C	209Y5A0174@ksrmce.ac.in
51	209Y5A0176	Parthasarathi Reddy Thammireddy	C	209Y5A0176@ksrmce.ac.in
52	209Y5A0180	Vinod Kumar Uppara	C	209Y5A0180@ksrmce.ac.in
53	209Y5A0181	Gayathri Vanthatipalli	C	209Y5A0181@ksrmce.ac.in
54	209Y5A0183	Sai Kumar Velligaram	C	209Y5A0183@ksrmce.ac.in
55	209Y5A0184	Jagan Mohan Reddy Vennapusa	C	209Y5A0184@ksrmce.ac.in
56	209Y5A0186	Madhava Reddy Vundela	C	209Y5A0186@ksrmce.ac.in
57	209Y5A0187	Hemadri Yatagiri	C	209Y5A0187@ksrmce.ac.in
58	209Y5A0189	Naga Mahendra Yerragorla	C	209Y5A0189@ksrmce.ac.in

Coordinator

HoD-Civil Engg.

Head
Department of Civil Engineering
K.S.R.M. College of Engineering
(Autonomous)
KADAPA 516 003. (A.P.)

Syllabus of Certification Course

Course Name: Liquefaction analysis of soil using FEA Media & IS1893-2015

Duration: 30 Hours

Module I:

Introduction to liquefaction, Propagation of harmonic motion of shear waves in one dimensional system, Description of the program shake.

Module II:

Soil Stratum, Input Motion, Soil Properties, Element Input, Predefined Materials, User-Defined Materials.

Module III:

Additional Viscous Damping, Step-By-Step Time Integration

Module IV

Running The Analysis, Response At A Location, Response Profile, Report Generator

Text Books:

I. M. Idriss & R. W. Boulanger, Soil Liquefaction During Earthquakes, Earthquake Engineering Research Institute, 2 edition, 2008.

II. Hughes, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Dover Publications Inc.; Illustrated edition, 2003

Head
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V. S. S. Murthy
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Department of Civil Engineering

Certification course

on

Liquefaction analysis of soil using FEA Media & IS1893-2015

Date	Timing	Course Instructor	Topic to be covered
17/05/21	4 PM to 6 PM	Sri. P. Suresh Praveen Kumar	Introduction to liquefaction
18/05/21	4 PM to 6 PM	Sri. P. Suresh Praveen Kumar	Propagation of harmonic motion of shear waves in one dimensional system
19/05/21	4 PM to 6 PM	Sri. P. Suresh Praveen Kumar	Propagation of harmonic motion of shear waves in one dimensional system
20/05/21	4 PM to 6 PM	Sri. P. Suresh Praveen Kumar	Description of the program shake
21/05/21	4 PM to 6 PM	Sri. P. Suresh Praveen Kumar	Soil Stratum, Input Motion, Soil Properties
22/05/21	2 PM to 6 PM	Sri. P. Suresh Praveen Kumar	Soil Stratum, Input Motion, Soil Properties
24/05/21	4 PM to 6 PM	Sri. P. Suresh Praveen Kumar	Element Input, Predefined Materials, User-Defined Materials
25/05/21	4 PM to 6 PM	Sri. P. Suresh Praveen Kumar	Element Input, Predefined Materials, User-Defined Materials
26/05/21	4 PM to 6 PM	Sri. P. Suresh Praveen Kumar	Additional Viscous Damping, Step-By-Step Time Integration
27/05/21	4 PM to 6 PM	Sri. P. Suresh Praveen Kumar	Additional Viscous Damping, Step-By-Step Time Integration
28/05/21	4 PM to 6 PM	Sri. P. Suresh Praveen Kumar	Running The Analysis, Response At A Location, Response Profile, Report Generator
29/05/21	2 PM to 6 PM	Sri. P. Suresh Praveen Kumar	Running The Analysis, Response At A Location, Response Profile, Report Generator
31/05/21	4 PM to 6 PM	Sri. P. Suresh Praveen Kumar	Running The Analysis, Response At A Location, Response Profile, Report Generator

V. S. S. Murthy

Principal

PRINCIPAL
K.S.R.M. COLLEGE OF ENGINEERING
KADAPA - 516 003. (A.P.)

Instructor:

Coordinators:

ACTIVITY REPORT

Certificate Course

On

"Liquefaction Analysis of soil using MEDIA & IS: 1893 - 2015"

17th May, 2021 to 31st May, 2021

Target Group	:	**Students**
Details of Participants	:	**58 Students**
Co-coordinator(s)	:	**Sri Ch. Santhosh Kumar and E. Manoranjitha**
Organizing Department	:	**Civil Engineering**
Mode	:	**Online (google meet)**
Link	:	**https://meet.google.com/lookup/egrubapw**

Description:

The Microsoft Windows-based interface user friendly geotechnical software for soil liquefaction analysis; It covers *liquefaction assessment* using various empirical methods, and estimation of *post-liquefaction lateral spread and re-consolidation settlement* of the site.

1) Convenient pre-processing (i.e., preparation of input data file)
2) Initiation and execution of the computations.
3) Display of the response (output)

4) Generation of an output report with the desired figures and relevant information. This interface is designed for simplicity, and is intended to be intuitive and self-explanatory. Start with the simplest possible model of the scenario you wish to study. As you gain confidence in the results, gradually proceed towards more elaborate simulations.

Photo:

Co-ordinator

Head
Department of Civil Engineering
K.S.R.M. College of Engineering
(Autonomous)
KADAPA 516 003. (A.P.)

V. S. S. Murthy
Principal
PRINCIPAL
K.S.R.M. COLLEGE OF ENGINEERING
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K.S.R.M. COLLEGE OF ENGINEERING

(UGC-AUTONOMOUS)

Kadapa, Andhra Pradesh, India- 516 003

Approved by AICTE, New Delhi & Affiliated to JNTUA, Ananthapuramu

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ESTD: 1980

DEPARTMENT OF CIVIL ENGINEERING

CERTIFICATE COURSE

on

"LIQUEFACTION ANALYSIS OF SOIL USING FEA MEDIA & IS: 1893-2015"

Resource person

Sri P. Suresh Praveen kumar
Assistant Professor
Department of Civil Engineering

17-05-2021
31-05-2021

Coordinators: Sri Ch. Santhosh Kumar and E. Manoranjitha

Assistant Professor, Civil Engg., KSRMCE

Department of Civil Engineering

Attendance sheet of Certification course on "Liquefaction analysis of soil using FEA Media & IS1893-2015"

Sl. No.	Student Roll No.	Student Name	17/05	18/05	19/05	20/05	21/05	22/05	24/05	25/05	26/05	27/05	28/05	29/05	31/05
1	199Y1A0109	Chennakeshava Dirasantha	a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	199Y1A0116	Venkata Sai Janapati	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3	199Y1A0122	Nagarathna Kumbhagiri	✓	✓	✓	a	✓	✓	✓	✓	✓	✓	✓	✓	✓
4	199Y1A0141	Divya Ragi	✓	✓	a	✓	a	✓	✓	✓	✓	✓	a	✓	✓
5	199Y1A0143	Hima Bindu Ravella	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
6	199Y1A0147	Sudharshan Sandella	✓	✓	a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
7	199Y1A0159	Venkata Sai Pavan Sravanaboina	a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
8	199Y1A0163	Zareena Tasneem Syed	✓	✓	✓	✓	✓	a	✓	✓	✓	✓	✓	✓	✓
9	199Y1A0167	Chandrasekhar Vadde	✓	✓	✓	a	✓	✓	✓	✓	✓	✓	✓	a	✓
10	209Y5A0101	Supraja Amarai	✓	✓	a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
11	209Y5A0102	Mahesh Amruthapuri	✓	a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
12	209Y5A0104	Surendra B	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	a

13	209Y5A0105	Chinna Obulesu Bandela	a	✓	✓	✓	✓	✓	✓	✓	✓	✓	a	✓	✓
14	209Y5A0106	Sreehari Battena	a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
15	209Y5A0109	Vishnu Vardhan Reddy Bollavaram	✓	✓	a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
16	209Y5A0110	Venkata Harsha Vardhini Boreddy	✓	✓	✓	✓	✓	✓	✓	✓	✓	a	✓	✓	✓
17	209Y5A0111	Rupesh C	✓	✓	a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
18	209Y5A0112	Upendra Chakali	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
19	209Y5A0114	Prudhviswar Reddy Chinnapareddy	✓	✓	✓	✓	a	✓	✓	✓	✓	✓	✓	✓	a
20	209Y5A0117	Jayadev Doppani	✓	✓	✓	✓	✓	✓	a	✓	✓	✓	✓	✓	✓
21	209Y5A0118	Surekha Duggireddy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
22	209Y5A0120	Harini G	✓	✓	a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
23	209Y5A0123	Veera Chandana Giddaluru	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
24	209Y5A0124	Geetha Nandini Gorige	a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
25	209Y5A0126	Venkata Sai Prasanna Jandlamaram	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	a	✓	✓
26	209Y5A0127	Boya Kondaiah Jeripiti	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	a

27	209Y5A0128	Kalinga Jukuru	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	a
28	209Y5A0129	Guru Vinod Kaluva	✓	✓	✓	✓	✓	✓	✓	a	✓	✓	✓	✓	✓
29	209Y5A0132	Jyothi Sujatha Kodivalasa	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	a	✓	✓
30	209Y5A0134	Ramakrishna Kondapuram	a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
31	209Y5A0137	Dwarakanath Reddy Levaku	✓	a	✓	✓	✓	✓	✓	✓	a	✓	✓	✓	✓
32	209Y5A0139	Venkata Naveen Kumar Maduru	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
33	209Y5A0141	Venkata Siva Mandem	a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
34	209Y5A0142	Sneha Mandugundu	✓	✓	a	✓	a	✓	✓	✓	✓	✓	✓	✓	✓
35	209Y5A0143	Ganesh Matamkari	✓	✓	✓	✓	✓	✓	✓	✓	a	✓	✓	✓	✓
36	209Y5A0145	Venkata Jagadeeshwar Reddy Mudamala	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	a	✓	✓
37	209Y5A0146	Kirankumar Reddy Mudiveti	✓	✓	✓	✓	a	✓	✓	✓	✓	✓	✓	✓	✓
38	209Y5A0147	Jithendra Reddy Mule	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	a	✓	✓
39	209Y5A0148	Hari Krishna Mutta	✓	✓	a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

40	209Y5A0150	Suneel Kumar Nandyala	a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
41	209Y5A0153	Sowjanya Nimmakayala	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	a
42	209Y5A0154	Ammeer Basha Pagadala	a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
43	209Y5A0156	Asma Paidepalli	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
44	209Y5A0157	Ramakumar Palla	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
45	209Y5A0158	Obula Reddy Pasam	✓	✓	a	✓	✓	✓	a	✓	✓	✓	✓	✓	✓
46	209Y5A0159	Ajay Kumar Pesala	✓	✓	✓	✓	✓	a	✓	✓	✓	✓	a	✓	✓
47	209Y5A0160	Madhusudhana Peyala	✓	✓	✓	✓	✓	✓	a	✓	✓	✓	✓	✓	✓
48	209Y5A0161	Lakshmana Pillagowla	✓	✓	✓	✓	a	✓	✓	✓	✓	✓	✓	✓	✓
49	209Y5A0170	Jaya Simha Santolla	✓	✓	✓	✓	✓	✓	✓	a	✓	✓	✓	✓	✓
50	209Y5A0174	Sohail Shaik	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
51	209Y5A0176	Parthasarathi Reddy Thammireddy	✓	✓	a	✓	✓	✓	✓	✓	✓	✓	a	✓	✓
52	209Y5A0180	Vinod Kumar Uppara	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	a	✓
53	209Y5A0181	Gayathri Vanthatipalli	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

54	209Y5A0183	Sai Kumar Velligaram	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
55	209Y5A0184	Jagan Mohan Reddy Vennapusa	✓	✓	✓	✓	✓	✓	✓	✓	✓	a	✓	✓	✓
56	209Y5A0186	Madhava Reddy Vundela	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
57	209Y5A0187	Hemadri Yatagiri	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
58	209Y5A0189	Naga Mahendra Yerragorla	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Coordinators

HoD-Civil Engg.

Head
Department of Civil Engineering
K.S.R.M. College of Engineering
(Autonomous)
KADAPA 516 003. (A.P.)

LIQUEFACTION ANALYSIS OF SOIL USING MEDIA & IS: 1893-2015

COURSE HANDOUT

Date of Event: 17.05.2021 to 31.05.2021

Resource Person

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Course Content

1. INTRODUCTION

Cyclic1D is a nonlinear Finite Element program for one-dimensional (1D) lateral dynamic site-response simulations. The program operates in the time domain, allowing for linear (Hughes 1987) and nonlinear studies. Nonlinearity is simulated by incremental plasticity models to allow for modeling permanent deformation and for generation of hysteretic damping. For analysis of dry as well as saturated strata, the finite elements are defined within a coupled solid-fluid (u-p) formulation (Chan 1988, Ziekiewicz et al. 1990). Dry and/or saturated soil profiles may be studied. In saturated cohesionless soil strata, liquefaction and its effects on ground acceleration and permanent deformation are modeled.Inthisregard,theusermaywishtoexploretheresponseofalevelgroundsite,or conversely to investigate the response of a mildly-inclined infinite-slopesite.

1.1 THEORY

1. The Microsoft Windows-based interface allows for: 1) convenient pre-processing (i.e., preparationofinputdatafile),2)initiationandexecutionofthecomputations,3)displayof the response (output), and 4) generation of an output report with the desired figures and relevant information. This interface is designed for simplicity, and is intended to be intuitive andself-explanatory. Start with the simplest possible model of the scenario you wish to study. As you gain confidenceintheresults,graduallyproceedtowardsmoreelaboratesimulations.Ifyouare a new user, consider running a simple case using one of the U-clay-rock models, and specify "Linear run". Under an earthquake excitation (with rigid base specified), you shouldobservethefundamentalresonanceatthefrequencyof$f_1 = V_s/4H$(in*Hz*),where$V_s$istheshearwavevelocityand*H*isthestratumheight(forexample,tryperhapsaV_s=200 m/sec and H = 50 m, with 50 elements for example, and check figures of Spectral amplification of acceleration relative to base motion). In this simple case, higher resonances should appear at $3f_1$, $5 f_1$, $7 f_1$and so forth. Note that these resonant responses will become more pronounced as you reduce the specified viscous damping. The actual numerical resonant frequencies should approach the above theoretical values as the specified number of elements modeling the stratum increases, and as the base excitation file time-step decreases (and also as the duration of base excitation increases, see Chopra 2000). For shear beam resonance, see Elgamal(1991).

2. The smaller, the element height, the higher the frequency content that the model is able to simulate. For traditional site response calculations, seismic excitation is usually primarily rich in frequencies of up to 15 Hz or thereabout. As you finalize your work, it might be worthwhile to run your model with a finer mesh (i.e., more elements), and to check that the results are of acceptable accuracy (i.e., the higher frequency response is becoming stable and is not changingsignificantly).
3. It is suggested to undertake this step only after you have verified that all modeling parameters are in good order, and that the resulting response is logical (in order to save time and effort). As a guideline (for linear analysis), the maximum frequency F_{max}that an element of shear wave velocity V_s, and height h can transmit is $F_{max} = (V_s/h) / 4.0$.
4. Make use of the available help buttons in the Windows Interface for additional clarifications
5. System Requirements: Cyclic1D runs on PC compatible systems using either Windows XP, Windows 7 or 8. The system should have a minimum hardware configuration appropriate to the particular operating system.
6. Installation: After downloading the Cyclic1D installation file, double-click on the icon and the installation procedure will start. Once installed, the default case in Cyclic1D is a good way to go through the steps involved in conducting a Cyclic1D analysis.
7. Theinterfacewillallowtheusertoprepareandsaveaninputfile,toruntheanalysis,andto display the response. A "Report Generator" facility allows users to save all or selected input parameters and responsefigures

1.2 PROPAGATION OF HARMONIC MOTION OF SHEAR WAVES IN ONE DIMENSIONAL SYSTEM

The evolution of the computer program SHAKE is typical of other FORTRAN programs originally developed for the mainframe environment in the 1970s. At that time, punched computer cards served to input data and the program output consisted of reams of numbers and crude graphical displays from a line printer. In the 1980s, the program was ported to the PC environment. The initial code changes were those necessary simply to get an executable program that ran on the engineer's desktop computer. Subsequent modifications have "tweaked" the program. The thrust of these modifications has been to ease construction of the input file and to provide a number of default settings for program operation and output. However, in its essentials, today's SHAKE is largely unchanged from its mainframe incarnation. It still is not "user friendly", but most importantly it is a robust analysis tool proven in some twenty-five years of service.Recent advances in computer technology, operating systems, and programming languages have allowed the developmentofcomputerprogramsthatgreatlysimplifythe processofenteringinputdataandpresentingtheresults in a more informative manner. Computer programs such as WESHAKE, ProShake and ShakEdit are examples of the trend towards the development of the next generation of user-friendly, Geotechnical Earthquake Engineering software. Thus, integrating an analysis program with a user-friendly interface facilitates and greatly enhances the interpretation of the dynamic behavior of a particular site. The integration of SHAKE and ShakEdit into an affordable, quality computer program is the next logical upgrade of the SHAKE computerprogram.

For those of you who are familiar with the many advances in dynamic analysis programs, you may wonder why invest this effort in a 33-year-old program for the one-dimensional, equivalent-linear analysis of site response? The short answer is that with a minimal input file, a "reasonable approximation" of the site response can be obtained with an analysis whose run time is a matter of seconds. Thus, the user has a powerful screening tool to gauge site response and then determine whether more sophisticated modeling is warranted. The development of WESHAKE by the Corps and ProShake by Dr. Steven Kramer, stand as a testament that others in the geotechnical community appreciate the intrinsic value in this venerable analysis procedure.

The following sections of this manual provide the user with a description of the SHAKE program. In the first sections, we have included the original documentation for the program to provide the user with the theoretical background followed in the development of SHAKE. Following this description of SHAKE, we have included a section about ShakEdit, the graphical user interface that was integrated with SHAKE to create this latest update. We then briefly describe the modifications to the original SHAKE source code for the development of SHAKE91 and SHAKE2000. The following section describes the methodology followed during a simplified seismic analysis, and the options used to perform this analysis with SHAKE2000. The second part of this manual starts with a step-by- step, quick tutorial intended to explain how to use SHAKE2000 by following a simple example that covers most of the features of the program. The last section of the manual describes each of the "forms" included in theprogram.

The analytical procedure generally involves the following steps:

- Determine the characteristics of the motions likely to develop in the rock formation underlying the site, and select an accelerogram with these characteristics for use in the analysis. The maximum acceleration, predominant period, and effective duration are the most important parameters of an earthquake motion. Empirical relationships between these parameters and the distance from the causative fault to the site have been established for different magnitude earthquakes (Gutenberg and Richter, 1956; Seed et. al., 1969; Schnabel and Seed, 1972). A design motion with the desired characteristics can be selected from the strong motion accelerograms that have been recorded during previous earthquakes (Seed and Idriss, 1969) or from artificially generated accelerograms (Housner and Jennings,1964).
- Determine the dynamic properties of the soil deposit. Average relationships between the dynamic shear moduli and damping ratios of soils, as functions of shear strain and static properties, have been established for various soil types (Hardin and Drnevich, 1970; Seed and Idriss, 1970). Thus, a relatively simple testing program to obtain the static properties for use in these relationships will often serve to establish the dynamic properties with a sufficient degree of accuracy. However more elaborate dynamic testing procedures are required for especial problems and for cases involving soil types for which empirical relationships with static properties have not beenestablished.
- Compute the response of the soil deposit to the base-rock motions. A one-dimensional method of analysis can be used if the soil structure is essentially horizontal. Programs developed for performing this analysis are in general based on either the solution to the wave equation (Kanai, 1951; Matthiesen et al., 1964; Roesset and Whitman, 1969; Lysmer et al., 1971) or on a lumped mass simulation (Idriss and Seed, 1968). More irregular soil deposits may require a finite elementanalysis.
- In the following sections, the theory and use of a computer program based on the one-dimensional wave propagation method are described. The program can compute the responses for a design motion given anywhere in the system. Thus accelerograms obtained from instruments on soil deposits can be used to generate new rock motions which, in turn, can be used as design motion for other soil deposits, see Fig. 1 (Schnabel et al., 1971). The program also incorporates nonlinear soil behavior, the effect of the

elasticity of the base rock and systems with variable damping.

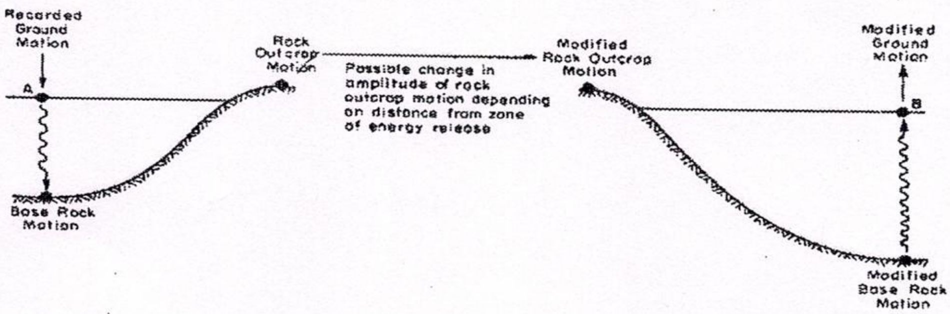


Figure 1: Schematic representation of procedure for computing effects of local soil conditions on ground motions (after Schnabel et al., 1972).

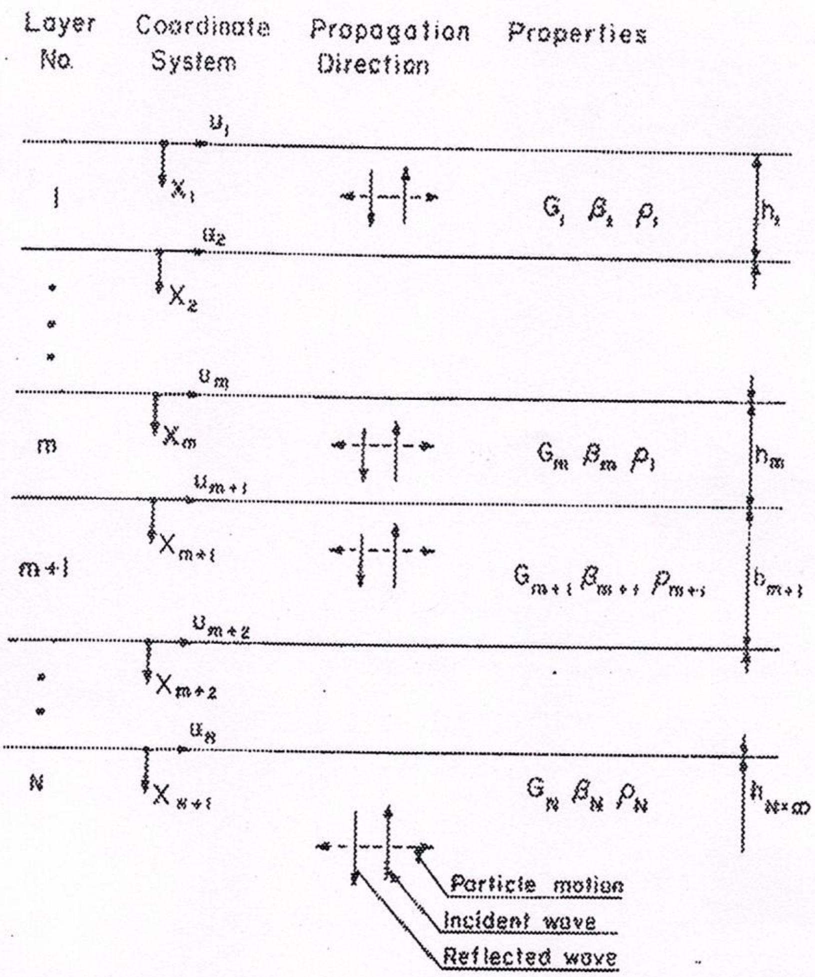


Figure 2: One-Dimensional System (after Schnabel et al., 1972).

1.3 DESCRIPTION OF THE PROGRAM SHAKE

Program SHAKE computes the response in a system of homogeneous, visco-elastic layers of infinite horizontal extent subjected to vertically traveling shear waves. The system is shown in Fig. 2. The program is based on the continuous solution to the wave equation (Kanai, 1951) adapted for use with transient motions through the Fast Fourier Transform algorithm (Cooley and Tukey, 1965). The nonlinearity of the shear modulus and damping is accounted for by the use of equivalent linear soil properties (Idriss and Seed, 1968; Seed and Idriss, 1970) using an iterative procedure to obtain values for modulus and damping compatible with the effective strains in each layer.

The following assumptions are implied in the analysis:

- The soil system extends infinitely in the horizontaldirection.
- Each layer in the system is completely defined by its value of shear modulus, critical dampingratio, density, and thickness. These values are independent offrequency.
- The responses in the system are caused by the upward propagation of shear waves from the underlyingrock formation.
- The shear waves are given as acceleration values of equally spaced time intervals. Cyclic repetition of the acceleration time history is implied in thesolution.
- The strain dependence of modulus and damping is accounted for by an equivalent linear procedurebased on an average, effective strain level computed for eachlayer.
- Theprogramisabletohandlesystems withvariationinbothmodulianddampingandtakesintoaccounttheeffect of the elastic base. The motion used as a basis for the analysis, the object motion, can be given in any one layer in the system and new motions can be computed in any otherlayer.

2.1 SOIL STRATUM

The following set of operations can be performed by the program:

- Read the input motion, find the maximum acceleration, scale the values up or down, and computethe predominantperiod.

- Read data for the soil deposit and compute the fundamental period of thedeposit.
- Compute the maximum stresses and strains in the middle of each sub layer and obtain new valuesfor modulus and damping compatible with a specified percentage of the maximumstrain.
- Compute new motions at the top of any sub layer inside the system or outcropping from thesystem.
- Print, plot and punch the motions developed at the top of anysub layer.
- Plot Fourier Spectra for themotions.
- Compute, print and plot response spectra for motions.
- Compute, print and plot the amplification function between any twosub layers.
- Increase or decrease the time interval without changing the predominant period or duration of therecord.
- Set a computed motion as anew object motion. Change the acceleration level and predominant period of the objectmotion.
- Compute, print and plot the stress or strain time-history in the middle of anysub layer.
- These operations are performed by exercising the various available options in the program. A list of these options is given in the following sections.

2.2 INPUT MOTION

ShakeEdit was originally developed as a 16-bit, Windows 3.1 application that provided a graphical interface for SHAKE. It was originally conceived as an aid to the user in the creation of the input file and the graphical display of the program's numeric output. It accomplished the first step by incorporating user-friendly screens to assist in entering the arcane input data for the differing SHAKE options. The second step required the development of routines for the processing and error checking of output data, and for displaying that output in forms familiar to the geotechnical engineer.

Notable features of ShakEdit as a preprocessor for SHAKE are thefollowing:

- On-line help for every form used in theprogram.
- A database of material properties [Option1].
- Incorporation of a number of equations used to estimate the maximum shear moduli, G_{max}[Option2].

The solution of a particular problem requires use of realistic ground motions (loading), modeling site dynamics (response), and the interpretation and prediction of soil behavior subject to dynamic loading (analysis). To help the engineer in the solution of this problem, ShakEdit evolved from its original formulation as strictly a pre and postprocessor for SHAKE, to a computer program that the practicing engineer could employ to address geotechnical aspects of earthquake engineering of a project site. It presently includes the following:

- Numerous ground motion prediction equations for estimating peak horizontal acceleration andvelocity with distance; and, for the pseudo acceleration and pseudo velocity responsespectra.
- Design spectra such as NEHRP, IBC, UBC 1997, EuroCode and AASHTO. These spectra and those from ground motion prediction equations can be plotted simultaneously with the spectra computed withSHAKE.
- Calculation of permanent slope displacements due to earthquake shaking using the Newmark Method or the Makdisi-SeedMethod.
- A postprocessor for SEISRISK III, a computer program for seismic hazard estimation developed bythe USGS.
- Computation of cyclic stress ratio (CSR) based on 1) equivalent uniform shear stress using the peakshear stress computed with SHAKE; or, 2) the simplified equation by Seed & Idriss(1971).
- Estimation of the cyclic resistance ratio (CRR) required to initiate liquefaction using SPT, CPT, V_s and/or BPT testresults.
- Calculation of settlement induced by earthquakeshaking.
- An option to obtain the Peak Ground Acceleration from the gridded points used to make the 1996USGS National Seismic Hazard Maps based on latitude and longitudeinput.
- Utilities to convert ground motion record files downloaded from the internet or obtained fromother sources to a format compatible with SHAKE.

2.3 SOIL PROPERTIES

Soil Profile Height: The Soil Profile Height is in meters.

Number of Elements: The Number of Elements can be chosen between 10 and 2000.

Water Table Depth: The Water Table Depth refers to the depth below ground surface (e.g., 0.0 corresponds to a fully saturated soil profile, 1.0 is 1m below ground surface). Dry sites should specify water table depth to be equal to the entire model depth.

Inclination Angle: The Inclination Angle is in degrees (Zero degree represents level ground). For mildly-inclined infinite-slopes, suggested values are from 0 to 10 degrees. **Bedrock:**A rigid base may be specified (corresponds to an infinitely rigid rock base). In this case, the base input excitation is actually the total acceleration occurring at the model base.

2.4 PREDEFINED MATERIALS

1. Shear wave velocities for rocks are based on International Code Council(1998). *2000 International Building Code (Final Draft)*.

2. There are two options for a user to define own rock: one is to use the same properties as the soil column at the bottom element; the other is that the properties are defined by theuser.

3. User-definedshearwavevelocityinm/s(suggestedvaluesbetween100and6000).

4. User-defined mass density in kg/m^3 (suggested values between 1300 and 2500 kg/m^3).

Otherthantherigidbasescenario,thespecifiedinputmotionaccelerationfileisconsidered to be the "incident" motion component only. As such, the program computes the total motion at the specified stratum-rock interface (i.e., sum of the incident and reflected waves). Incident motion files may sometimes be obtainedby:

- Using a recorded rock-outcrop acceleration file with the amplitudes scaled to ½ of the recordedvalues(assumingtherockoutcroptobeessentially"Rigid",incidentmotioniso f the recorded ground surface motion).
- Using an appropriate program that allows de-convolution, (e.g., the well-known program SHAKE, Schnabel et al. 1972), starting with a ground surface rock-

outcrop motionandcomputingthemotionatthedesiredbase-inputdepth.FromtheSHAKEresult, define the incident motion at the desired depth for use in Cyclic1D. This incident motion (upward propagating waves) is ½ of the SHAKE-computed so-called "outcrop motion" at the desired depth, orStartingatthesurfacewitharecordedgroundsurfaceaccelerationrecordandattemptin g tode-convolvethismotionusingSHAKEforinstance(asdescribedabove).Thisapproach has been known to be problematic and is notrecommended.

2.5 USER DEFINED MATERIALS

There are 30 user-defined materials including 10 clay/rock materials with properties independentofconfinementvariationand10sandymaterialswithconfinement-dependent material properties. Some user-defined materials do not take into account dynamic pore pressure generation effects. Therefore, this class of materials is suitable for soil layersthat are not susceptible to significant pore pressure variation during earthquake excitation. To define the parameters of a user-defined material, click on the button associated with that material and fill in the pop-upwindow.

- User Defined Clay/Rock Strata with No Pore-Pressure Effects
- Non-liquefiable clayey/rock strata with shear response properties independent of confinement variation can be defined by specifying the following parameters.
- Mass density in kg/m^3 (suggested range of values between 1000 and 3000kg/m^3).
- Shear wave velocity in m/s (suggested range of values between 10 and6000m/s).
- Initial lateral/vertical stress ratio (also known as coefficient of lateral earth pressure at restK_0,suggestedrangeofvaluesbetween0.1and0.9.Intheprogram,K_0isrelatedto
- Poisson's ratio by the following relation.
- Shear strength in kPa (suggested range of values between 10 and 200000kPa).
- Peak shear strain in % (suggested range of values between 0.001% and20%).

Bedrock type	Shear wave velocity[1] (m/s)	Mass density (kg/m^3)

Soft Rock	700	2500
Rock	1100	2500
Hard Rock	1600	2500
U-Rock (User-defined) [2]	(User-defined) [3]	(User-defined) [4]

- Number of yield surfaces (NYS). Suggested range of values is

4.1 Running the Analysis

To run the analysis, click “Save Model & Run Analysis” in Menu “Analyze” or “Save Model & Run Analysis” Button at the bottom of the Model Input window.

Upon the user requests to run the analysis, Cyclic1D will check all the entries defined by theusertomakesurethemodelisvalid.Thereafter,asmallwindowwillshowtheprogress of theanalysis.

By default, graphical output windows will be opened upon completion of the analysis.

To only verify if the input model is valid, choose “Check Input Data” in Menu “Analyze”.

4.2 Response at a Location

To view the response time histories, click “View Response Histories” in Menu “Output”.

The figures show the response histories at different depths (0m at ground surface and the largest at the bottom of the soil column).

Seven types of response time histories are available:

- Horizontal Acceleration TimeHistory
- Response Spectrum of Acceleration (shown versusPeriod)
- Response Spectrum of Acceleration (shown versusFrequency)
- Fourier Transform Amplitude ofAcceleration
- Spectral amplification of acceleration relative to basemotion
- Horizontal Displacement TimeHistory
- Excess Pore Pressure TimeHistory
- Shear Stress versus. ShearStrain
- Shear Stress versus. EffectiveConfinement

To zoom-in or zoom-out, use mouse to select a window. Click "fill" to get back to the original figure.

4.3 RESPONSE PROFILE

To view the response profiles, click "View Response Profile" in Menu "Output". The figuresshowresponseprofilesofthemodel.Seventypesofresponseprofilesareavailable:

- HorizontalDisplacement
- HorizontalAcceleration
- Excess PorePressure
- EffectiveConfinement
- ShearStrain
- ShearStress

To zoom-in or zoom-out, use mouse to select a window. Click "fill" to get back to the original figure.

Response at a Location

By default, the check box "Include all figures of response at 0m depth (surface)" is checked.Inthiscase,thereportwillincludeallseventypesofresponsetimehistoriesatthe surface (0mdepth):

- Horizontal Acceleration TimeHistory
- Response Spectrum ofAcceleration
- Fourier Transform Amplitude of Acceleration (versusFrequency)
- Fourier Transform Amplitude of Acceleration (versusPeriod)
- Spectral Amplification of Acceleration relative to basemotion
- Horizontal Displacement TimeHistory
- Excess Pore Pressure TimeHistory
- Shear Stress versus. ShearStrain
- Shear Stress versus. EffectiveConfinement

4.4 REPORT GENERATOR

SHAKE2000 was developed to provide the user with a user-friendly interface for SHAKE and to add newfeatures to transform it into an analysis tool for seismic analysis of soil deposits and earth structures. To this end, there are three ways that SHAKE2000 can beused.

One approach to work with SHAKE2000 is to use the different features included in the **Main Menu** form to work with an existing input file or output files.

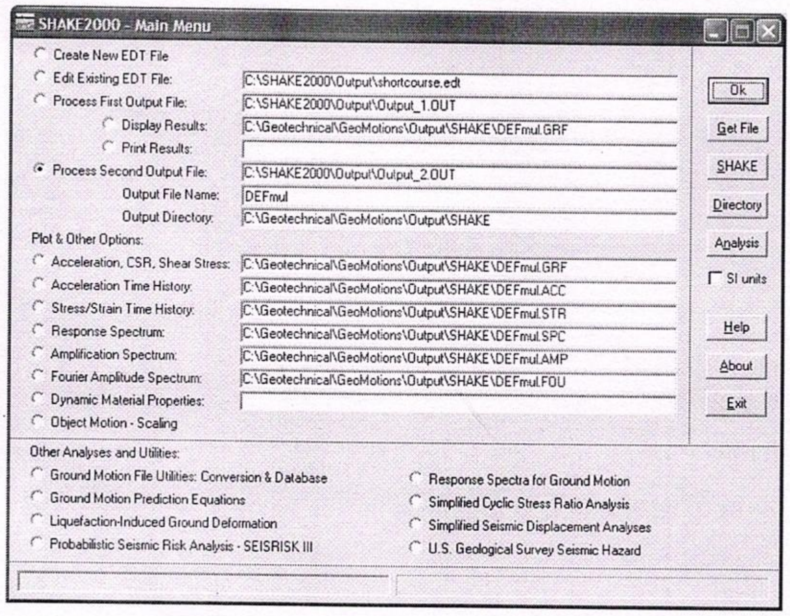
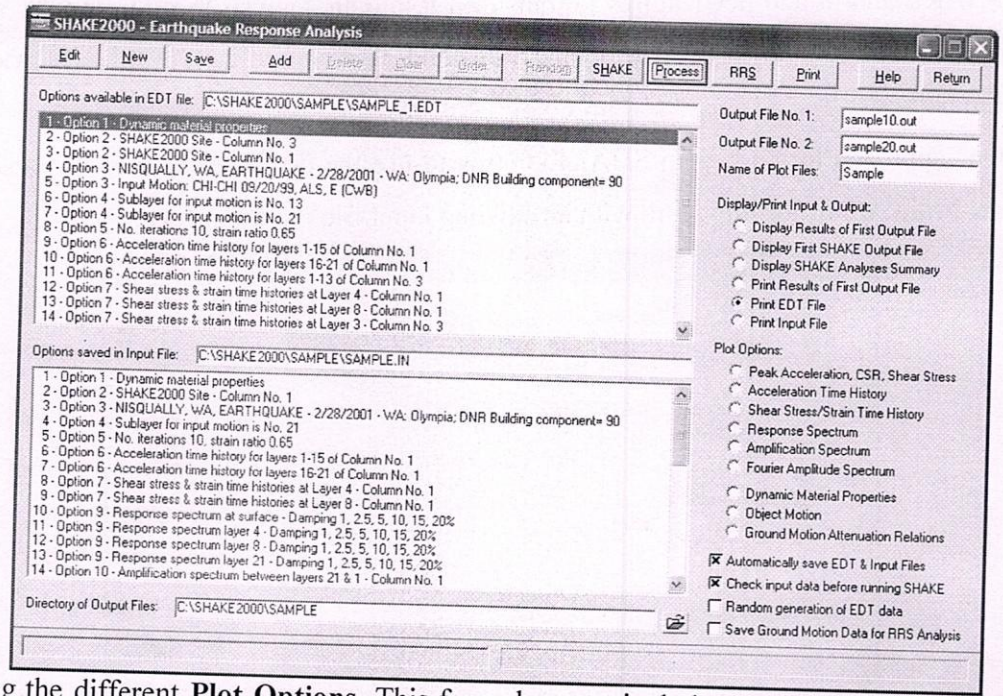


Figure 5: Main Menu form of SHAKE2000.

In this form, you can use the **SHAKE** command button to perform the earthquake response analysis and create the two output files. You can then use the **Process First Output File** and **Process Second Output File** options to obtain the most significant results from the output files. These results can be plotted with the **Plot Options** (e.g. **Peak Acceleration, CSR, Shear Stress**, etc.).

A second alternative is to use the options included in the **Earthquake Response Analysis** form (see Figure 6) by using either the **Create New EDT File** or the **Edit Existing EDT File** option in the **Main Menu** form. This form is mainly used to create a new working file for SHAKE2000, or to edit an existing file. You would first use the **Edit** command button to open different forms to enter/edit the data for each option that may be used for a SHAKE analysis. Then, use the **Add** button to select only those options you want to use in your analysis to create the input file, and the **SHAKE** button to perform the earthquake response analysis. After the analysis terminates, the **Process** button is used to obtain the most significant results from the output files. The results can be graphically presented by



using the different **Plot Options**. This form does not include the options available in the **Main Menu** form to perform other seismicanalyses.

Figure 2: Earthquake response analysis

A third way SHAKE2000 can be applied as a tool in seismic analysis is to use any of the **Other Analyses** options in the **Main Menu** form (e.g. **Simplified Cyclic Stress Ratio Analysis (Seed & Idriss 1971)**) to perform other seismic analyses, or to provide the user with supporting data (e.g. **Ground Motion Prediction Equations**).SHAKE is a FORTRAN computer program originally developed based upon a batch-file format, i.e. a sequential series of options saved in an ASCII (i.e. text) input file control the operation of the program. Each option is formed by a number of "formatted" values, i.e. the values should be between specific columns. This was a major drawback in the execution of SHAKE because either a misplaced value could crash the program, or the program could yield erroneous results. This has been overcome with SHAKE2000, which includes user-friendly screens for each option that provide the user with a simple way of entering the data. SHAKE2000 automatically saves the values in their expected "positions" in the input file.

In Geotechnical Earthquake Engineering practice, a model of the problem to be analyzed with SHAKE is widely known as a SHAKE Column. For convenience, we will adopt this term for use in this User's Manual. In order to set up a SHAKE Column to run an analysis with SHAKE2000, four components of the problem must be specified:

1. A one-dimensional (i.e. 1-D) representation of the soil profile, further divided intolayers.
2. Material properties for each layer of the SHAKE Column (e.g. G/G_{max} and Damping Ratio vs. strain curves, unit weight, thickness,etc.).
3. An acceleration time history representative of the design/analysis earthquake, and the location wherethe motion is assigned in the SHAKEColumn.
4. Selection of the results needed from theanalysis.

Each of the above components is represented in SHAKE2000 by one or more options. A short description of the options that can be used to perform a SHAKE analysis is provided below. For a more detailed explanation of each option, please refer to the following section of this manual.

The options incorporated into SHAKE and supported in SHAKE2000 are as follows: Option Description

- dynamic soilproperties
- data for soilprofile
- input (object)motion
- assignment of object motion to the top of a specified sublayer or to the correspondingoutcrop
- number of iterations specified & ratio of uniform strain to maximumstrain
- sublayers at top of which peak accelerations & time histories are computed andsaved
- sublayer at top of which time history of shear stress or strain is computed andsaved
- responsespectrum
- amplification spectrum
- Fourier amplitudes

Input Options that provide SHAKE with input data: Options 1, 2, 3, 4 and5.Analysis Options that direct SHAKE to use the input data to analyze the problem: Options 6, 7, 9, 10and To create a SHAKE Column, the user needs to first collect some preliminary information such as detailed subsurface profile information (e.g. geotechnical exploration), and to evaluate seismic information and select appropriate design earthquake events (e.g. seismic hazard analysis). The former will provide the user with information about soil layer distribution and thickness, soil types, groundwater level, depth to bedrock, unit weight, shear wave velocities, SPTs, fines content, etc. The latter will provide the user with: an estimate of the peak ground acceleration at the site; an estimation of a target response spectrum; the assessment of the earthquake magnitude associated with this peak ground acceleration; and, the selection of representative acceleration time histories whose response spectrum reasonably match the target response spectrum, or selection of ground motions recorded from similar earthquakes for similar sites at comparable distances, or artificial ground motions, etc.. More detailed information about these preliminary steps is beyond the scope of this User's Manual, and can be obtained from several references in geotechnical earthquake engineering.

Once the above information has been collected, the user can start creating an input file for SHAKE. The first step is to divide the soil profile into "layers". These layers do not necessarily need to match the different stratigraphic units in the soil profile. However, a layer should not be formed by two different "soil types". For example, a soil profile is shown in Figure 7 with a layering distribution for the SHAKE Column. Note that there are 4 main stratigraphic units (i.e. soft silt, medium dense sand, medium dense to dense silty sand, and very dense sand and gravel). Each stratigraphic unit has been subdivided in "layers" that represent each unit in the SHAKE Column (e.g. the Soft Silt unit is now represented in the SHAKE Column by layers number 1 and 2). In this manual, a stratigraphic unitcould be a soil or another material such as layer of waste in a landfill. A maximum of 200 layers can be used in a SHAKE Column.

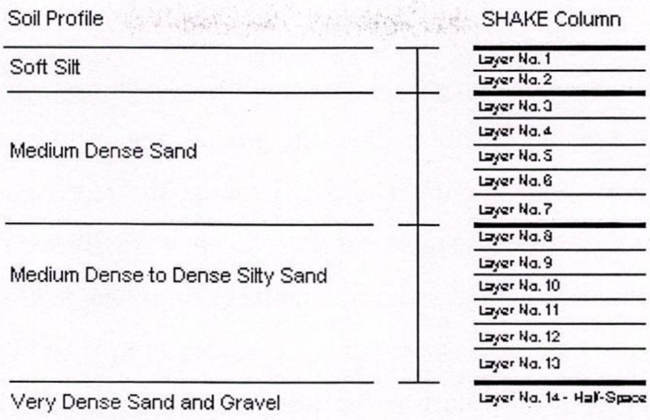


Figure 7: Example Soil Profile and SHAKE Column

The next step is the selection of dynamic material properties for each soil type. In SHAKE, the soil behavior under irregular cyclic loading is modeled by using modulus reduction (G/G_{max}) and damping vs. strain curves. The data for these curves are entered in Option 1. Each curve is formed by up to 20 strain and G/G_{max} or values.Information on curves for different materials has been published in different journals, and a few are included in the database of material properties provided with SHAKE2000.

These curves are entered sequentially in Option 1, and are assigned an index number based on the order they occupied in Option 1. For example, in option 1 of Figure 8 there are G/G_{max} and □ curves for two materials: Sand and Rock. The Sand would be assigned an index number of 1 and the rock a 2. This indexing is used in option 2 to assign a set of curves to each layer in the SHAKE Column.

Following the selection of layers and dynamic material properties, the user needs to enter the specific data for each layer that form the SHAKE Column. This is done in Option 2. The data required for each layer include: the soil type which correspond to a set of G/G_{max} and □ curves entered in Option 1above (e.g. if the layer in the SHAKE Column was part of a sand strata in the soil profile, and using the data in Option 1 shown in Figure 8, we will then assign a value of **1** for the soil type in this layer); the thickness of the layer; the maximum shear modulus (G_{max}) or the maximum shear wave velocity (V_s); an initial estimate of damping; and, the total unit weight of the material. For the calculation of G_{max}, SHAKE2000 includes several equations based on other input parameters (e.g. K_{2max}, N, q_c, etc.).

After the soil profile has been physically represented through options 1 and 2, the user needs to provide SHAKE with information about the ground motion to be applied to the SHAKE Column. This is done with options 3 and 4. Usually, the representative acceleration time history selected for the analysis is provided as a computer ASCII/text file. In option 3 the user enters data about this file such as maximum number of values (e.g. **3800** in Figure 8); path (e.g. directory in your hard disk where the file is saved, **sample** in Figure 8) and name of the file (**sample1.eq** in Figure 8); the way the values are read from the file (i.e. the format, for example **(8F9.6)** in Figure 8; also the ground motion file shown in Figure 9 has a format of 8F9.6, which means that the values are stored as 8 columns, or 8 values per line, each value formed by 9 figures, and of these 9 figures 6 form the decimal part of the value); number of header lines in the file (e.g. **1** in Figure 8, or **3** in Figure 9); and, the number of acceleration values per line in the file (e.g. **8** in Figure 8). Other information provided in Option 3 refers to the acceleration time history itself, such as the time interval between acceleration values (e.g. **0.01** in Figure 8); a multiplication factor for adjusting acceleration values (e.g. **1** in Figure 8) or the maximum acceleration to be used, i.e. the acceleration values read-in will be scaled to provide the maximum acceleration (in Figure 8 these columns were left blank); and, maximum frequency (i.e. frequency cut-off) to be used in the analysis.

SHAKE2000 Input File

Option 1 - Dynamic Soil Properties Set No. 1 1

2							
9	SandS1	G/Gmax - S1 (SAND CP<1.0 KSC) 3/111988					
0.00010.000316		0.001	0.00316	0.01	0.0316	0.1	0.316
1.00							
1.00	0.978	0.934	0.838	0.672	0.463	0.253	0.14
0.057							
9	Sand	Damping for SAND, February1971					
0.0001	0.001	0.003	0.01	0.03	0.1	0.3	1.00
10.00							
1.00	1.6	3.12	5.8	9.5	15.4	20.9	25.00
30.00							
8	Rock	G/Gmax - ROCK (Schnabel1973)					

0.0001	0.0003	0.001	0.003	0.01	0.03	0.1	1.00
1.00	1.00	0.99	0.95	0.9	0.81	0.725	0.55

5 Rock Damping for ROCK (Schnabel 1973)
0.0001 0.001 0.01 0.1 1.00

0.4 0.8 1.5 3.00 4.6

2 1 2

Option 2 - SHAKE2000 Site - Column No. 1 2

1 10 SHAKE2000 Site - Column No.1

1	1	5.5	753.0	0.05	0.13	
2	1	3.3	890.0	0.05	0.13	
3	1	3.3	858.0	0.05	0.13	
4	1	3.3	945.0	0.05	0.13	
5	1	3.3	1146.0	0.05	0.13	
6	1	3.3	1470.0	0.05	0.13	
7	1	3.3	1683.0	0.05	0.13	
8	1	3.3	1737.0	0.05	0.13	
9	1	3.3	1867.0	0.05	0.13	
10	2			0.05	0.15	2500.0

Option 3 - Input motion SAMPLE1.EQ 3

38004096 0.01 (8F9.6)

c:\shake2000\sample\sample1.eq

1 15 1 8

Option 4 - Sublayer for input motion is No. 10 4

10 1

Option 5 - No. iterations 10, strain ratio 0.65

5

10 0.65

Option 6 - Acceleration time history for layers 1-10 of Column No. 1 6

1	2	3	4	5	6	7	8	9	10
0	1	1	1	1	1	1	1	1	1
1	0	0	1	0	0	0	1	0	0

Option 7 - Shear stress & strain time histories at Layer 4 - Column No. 1 7

4 0 1 2048 SHAKE2000 Site - Column No. 1
4 1 1 2048 SHAKE2000 Site - Column No. 1

Option 9 - Response spectrum at surface - Damping 1, 2.5, 5, 10, 15, 20%

9

1 0

6 0 32.2

0.01 0.025 0.05 0.1 0.15 0.2

Option 10 - Amplification spectrum between layers 10 & 1 - Column No. 1 10

10 1 1 0 0.125 Surface/half-space Option

11 - Fourier spectrum for layers 1 & 10 of Column No.1

11

1 0 2 3 2048
10 1 2 3 2048

Execution will stop when program encounters 0

LOMA PRIETA EARTHQUAKE, LOS GATOS 10/18/89 - 90 degree - Near Fault Rock; PEER Ground Motion
LGPC V Loma Prieta Eqk,17 Oct 89, 37 01.32E, 122 00.61W,UCSCStation

No.Points:5008 Time Step: 0.005sec

-0.000029-0.000492-0.000793-0.000934-0.000959-0.000922-0.000866-0.000819

-0.000791-0.000782-0.000785-0.000794-0.000801-0.000804-0.000803-0.000798

-0.000792-0.000785-0.000779-0.000775-0.000771-0.000768-0.000765-0.000763

……………..

……………….

-0.033553-0.033664-0.033882-0.033816-0.032826-0.030158-0.025254-0.018188

-0.010279 0.000000 0.000000 0.000000 0.000000 0.000000 0.0000000.000000

In Option 4 this motion is assigned at the top of a sub layer and is input as either a rock outcrop or at the bedrock-soil interface at the base of the SHAKE Column. The last of the Input Options is Option 5. As noted before, SHAKE uses an iterative procedure to calculate the shear moduli and damping corresponding to the computed shear strains. This process ends when the maximum number of iterations is reached or when convergence between the estimated and computed strain amplitudes occurs. Accordingly, the user enters a value for the maximum number of iterations he other parameter entered in option 5 is the ratio between the effective and maximum strain. In each iteration, the strains used to obtain new values of strain-dependent modulus and damping ratio are a fraction of the peak strain computed from the previous iteration. From this option, results for maximum strain and maximum stress at the mid-point are obtained for eachlayer.

After the Input Options are created, you can use the Analysis Options to conduct a seismic site response analysis of the SHAKE Column. With these options you can obtain peak acceleration values and acceleration time histories at the top of specific layers (option 6), shear stress/strain time histories at the top of a layer (option 7), response spectra at the top of specific layers, amplification spectrum between any two layers (option 10), and Fourier spectrum at specific layers (option 11).

In option 6 the user first enters the number of the layers at which peak acceleration values and acceleration time histories are to be computed (e.g. **1 2 3 . …. 10**). Next, for each layer in the first row, a code describing the layer as an outcrop, or as within the soil profile, is entered in the second row (e.g. **0 1 1 ….. 1**).

Then, in the last row you enter for each layer in the first row a **1** (one) to indicate if an acceleration time history at the top of the layer is to be computed and saved in the output file, or a **0** (zero) otherwise (e.g. **1 0 0 1 …. 0** in Figure 8). It is recommended that you include every layer of the SHAKE Column in this option. When you have more than 15 layers, then additional sets of option 6 can be used to include the remaining layers in groups of up to 15 layers.

Option 7 is used to obtain time histories of shear stress or shear strain at the top of a specified layer. You need to enter the number of the layer, a code of 0 (zero) to compute the strain time history or 1 (one) to computethestresstimehistory,thenumberofvaluesofthetimehistorytobesaved intheoutput file, and a label or identification that describes the time history (e.g. **SHAKE2000 Site – Column No. 1**. You can use the second line to either obtain the other time history (e.g. in Figure 8 the first row the strain time history was selected, so in the second row the stress time history will be computed), or obtain the stress or strain time history for a differentlayer.

Response spectra at the top of specified layers are obtained with Option 9. For this option, you need to enter first the layer at which the spectra are to be computed (e.g. **1** for the surface layer in Figure 8), then a code that defines the layer as an outcrop or within the soil profile (e.g. **0** to define the layer as an outcrop). Then, enter the value for the acceleration of gravity, and finally the values of damping ratio for which spectra are to be computed (e.g. **0.01 0.025 .... 0.2** in Figure 8). In SHAKE2000, you don't need to enter the number of damping ratios used in the analysis. This number is changed automatically every time you enter or delete a value of damping ratio.

Table 1: Effect of the Higher Frequencies on the Maximum Accelerations and Strains (after Schnabel et al., 1972)

Depth	Maximum acceleration, g's		Difference	Maximum strain, %		Difference
	f_{max} = 25 c/sec	5 c/sec	%	f_{max} = 25 c/sec	5 c/sec	%
0	0.0971	0.0962	0.9			
7	0.0958	0.0949	0.3	0.00725	0.00724	0.1
20	0.0600	0.0599	0.1	0.1292	0.1283	0.7
30	0.0553	0.0556	0.6	0.0391	0.0390	0.3
42	0.0508	0.0507	0.2	0.0287	0.0287	-
62	0.0470	0.0469	0.2	0.00982	0.00989	0.7
80	0.0319	0.0299	6.3	0.0505	0.0504	0.2
100	0.0239	0.0235	1.7	0.0349	0.0348	0.3
120	0.0178	0.0189	6.2	0.0320	0.0319	0.3

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For instance if coeff is 0.5, then $G = (G_{ref})(p'/(p'_{ref}))$ ^0.5 and consequently $V_s = (V_{sref})(p'/(p'_{ref}))$ ^0.25

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Appendix II: Built-in Soil Materials in Cyclic1D: Parameters and Units: Notation and Symbols (please also see relevant manual sections about soil material models)

Mass density (kg/m^3)	ρ
Reference shear wave velocity (m/s)	V_s ref
Reference effective mean confinement (kPa)	p' ref
Confinement dependence coeff.	coeff
Initial lateral/vertical confinement ratio	K_0
Cohesion (kPa)	c
Friction angle (degree)	φ
Peak shear strain (%)	γ_{max}
Number of yield surfaces	NYS
Dilation or Phase Transformation (PT) angle (degree)	PT angle
Contraction parameter 1	c1
Contraction parameter 2	c2
Dilation parameter 1	d1
Dilation parameter 2	d2
Liquefaction parameter 1	Liq
Permeability coefficient (m/s)	Perm k

Notes:

1. The3parametersbelowarenotdirectlydefinedintheCyclic1Duserinterface.Instead, theshearwavevelocity$V_s$andtheinitiallateral/verticalconfinementratioK_0(K_0=ν/(1-ν) aredefined.$V_s$equaltoSqrt(G/ρ)allowsGtobecalculated.FromK_0,νiscalculatedand G and ν are used to calculateB.

Shear modulus (kPa)	G
Bulk modulus (kPa)	B
Poisson's Ratio	ν

2. p' is the effective mean confinement equal to ((σ_v' + σ_h' + σ_h')/ 3), where σ_v' is the vertical effective stress = ρ ' x depth and ρ ' is ρ for dry soil and is taken automatically as (ρ '-ρ_{water}) for saturated soil. In the above, σ_h is horizontal confinement K_0 x σ_v (or for saturated soil σ'$_h$ is K_0 xσ'$_v$).

3. Variation of shear modulus with confinement p' is defined by:
G =(G_{ref})(p'/(p'$_{ref}$))^coeff (note that p' = p for drysoil)

Initial-stress-state Parameters

SoilType \ Unit	ρ kg/m3	G kPa	B kPa	ν	$V_{s\,ref}$ m/s	p' ref kPa	coeff	K_0
1. Loose Silt	1700	5.80E+04	1.80E+05	0.4	184.7	80	0.5	0.67
2. Loose Sand	1700	5.80E+04	1.80E+05	0.4	184.7	80	0.5	0.67
3. Loose Gravel	1700	5.80E+04	1.80E+05	0.4	184.7	80	0.5	0.67
4. Medium Silt	1900	7.85E+04	2.40E+05	0.4	203.3	80	0.5	0.67
5. Medium Sand	1900	7.85E+04	2.40E+05	0.4	203.3	80	0.5	0.67
6. Medium Gravel	1900	7.85E+04	2.40E+05	0.4	203.3	80	0.5	0.67
7. Med-Dense Silt	1999	1.00E+05	3.00E+05	0.4	223.7	80	0.5	0.67
8. Med-Dense Sand	1999	1.00E+05	3.00E+05	0.4	223.7	80	0.5	0.67
9. Med-Dense Gravel	1999	1.00E+05	3.00E+05	0.4	223.7	80	0.5	0.67
10. Dense Silt	2100	1.35E+05	4.00E+05	0.4	253.5	80	0.5	0.67
11. Dense Sand	2100	1.35E+05	4.00E+05	0.4	253.5	80	0.5	0.67
12. Dense Gravel	2100	1.35E+05	4.00E+05	0.4	253.5	80	0.5	0.67
13. Cohesive Soft	1300	1.30E+04	2.00E+05	0.4	100	50	0	0.67
14. Cohesive Med	1500	6.00E+04	3.00E+05	0.4	200	50	0	0.67
15. Cohesive Stiff	1800	1.62E+05	8.00E+05	0.4	300	50	0	0.67

Stress-strain and Permeability Parameters (see relevant manual sections about soil models)

SoilType\ Unit	c kPa	φ deg	γ_{max} %	NYS	PT angle deg	c1	c2	d1	d2	Liq	Perm k m/s
1. Loose Silt	0.3	29	5	20	30	0.3	0.2	0	10	0.025	1.00E-07
2. Loose Sand	0.3	29	5	20	30	0.3	0.2	0	10	0.025	6.60E-05
3. Loose Gravel	0.3	29	5	20	30	0.3	0.2	0	10	0.025	1.00E-02
4. Medium Silt	0.3	31.4	5	20	26.5	0.19	0.2	0.2	10	0.015	1.00E-07
5. Medium Sand	0.3	31.4	5	20	26.5	0.19	0.2	0.2	10	0.015	6.60E-05
6. Medium Gravel	0.3	31.4	5	20	26.5	0.19	0.2	0.2	10	0.015	1.00E-02
7. Med-Dense Silt	0.3	35	5	20	24	0.06	0.5	0.4	10	0.01	1.00E-07
8. Med-Dense Sand	0.3	35	5	20	24	0.06	0.5	0.4	10	0.01	6.60E-05
9. Med-Den. Gravel	0.3	35	5	20	24	0.06	0.5	0.4	10	0.01	1.00E-02
10. Dense Silt	0.3	40	5	20	22	0.01	0.6	0.6	10	0.003	1.00E-07
11. Dense Sand	0.3	40	5	20	22	0.01	0.6	0.6	10	0.003	6.60E-05
12. Dense Gravel	0.3	40	5	20	22	0.01	0.6	0.6	10	0.003	1.00E-02
13. Cohesive Soft	18		5	20							1.00E-09
14. Cohesive Med.	37		5	20							1.00E-09
15. Cohesive Stiff	75		5	20							1.00E-09

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Course Duration: 30 Hours;
From 17/05/21 to 31/05/21

Course Instructor:
Sri. P. Suresh Praveen Kumar,
Assistant Professor, CE, KSRMCE-Kadapa

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4	Divya Ragi	199Y1A0141	Yes	Yes	4	Yes	5
5	Hima Bindu Ravella	199Y1A0143	Yes	Yes	4	Yes	4
6	Sudharshan Sandella	199Y1A0147	Yes	Yes	5	Yes	5
7	Venkata Sai Pavan Sravanaboina	199Y1A0159	Yes	Yes	5	Yes	5
8	Zareena Tasneem Syed	199Y1A0163	Yes	Yes	5	Yes	5
9	Chandrasekhar Vadde	199Y1A0167	Yes	Yes	5	Yes	5
10	Supraja Amarai	209Y5A0101	Yes	Yes	5	May be	5
11	Mahesh Amruthapuri	209Y5A0102	Yes	Yes	4	May be	5
12	Surendra B	209Y5A0104	Yes	Yes	5	Yes	5
13	Chinna Obulesu Bandela	209Y5A0105	Yes	Yes	5	Yes	5
14	Sreehari Battena	209Y5A0106	Yes	Yes	5	Yes	5
15	Vishnu Vardhan Reddy Bollavaram	209Y5A0109	Yes	Yes	4	Yes	5

16	Venkata Harsha Vardhini Boreddy	209Y5A0110	Yes	Yes	5	Yes	5
17	Rupesh C	209Y5A0111	Yes	Yes	3	Yes	4
18	Upendra Chakali	209Y5A0112	Yes	Yes	5	Yes	5
19	Prudhviswar Reddy Chinnapareddy	209Y5A0114	Yes	Yes	5	Yes	5
20	Jayadev Doppani	209Y5A0117	Yes	Yes	5	May be	5
21	Surekha Duggireddy	209Y5A0118	Yes	Yes	5	May be	5
22	Harini G	209Y5A0120	Yes	Yes	5	Yes	5
23	Veera Chandana Giddaluru	209Y5A0123	Yes	Yes	5	Yes	5
24	Geetha Nandini Gorige	209Y5A0124	Yes	Yes	5	Yes	5
25	Venkata Sai Prasanna Jandlamaram	209Y5A0126	Yes	Yes	5	Yes	5
26	Boya Kondaiah Jeripiti	209Y5A0127	Yes	Yes	5	Yes	5
27	Kalinga Jukuru	209Y5A0128	Yes	Yes	4	Yes	5
28	Guru Vinod Kaluva	209Y5A0129	Yes	Yes	4	May be	4
29	Jyothi Sujatha Kodivalasa	209Y5A0132	Yes	Yes	5	Yes	5
30	Ramakrishna Kondapuram	209Y5A0134	Yes	Yes	5	Yes	5
31	Dwarakanath Reddy Levaku	209Y5A0137	Yes	Yes	5	Yes	5
32	Venkata Naveen Kumar Maduru	209Y5A0139	Yes	Yes	5	Yes	5
33	Venkata Siva Mandem	209Y5A0141	Yes	Yes	5	Yes	5

34	Sneha Mandugundu	209Y5A0142	Yes	Yes	5	Yes	5
35	Ganesh Matamkari	209Y5A0143	Yes	Yes	5	Yes	5
36	Venkata Jagadeeshwar Reddy Mudamala	209Y5A0145	Yes	Yes	3	May be	4
37	Kirankumar Reddy Mudiveti	209Y5A0146	Yes	Yes	5	Yes	5
38	Jithendra Reddy Mule	209Y5A0147	Yes	Yes	5	Yes	5
39	Hari Krishna Mutta	209Y5A0148	Yes	Yes	5	May be	5
40	Suneel Kumar Nandyala	209Y5A0150	Yes	Yes	4	Yes	4
41	Sowjanya Nimmakayala	209Y5A0153	Yes	Yes	5	Yes	5
42	Ammeer Basha Pagadala	209Y5A0154	Yes	Yes	5	Yes	5
43	Asma Paidepalli	209Y5A0156	Yes	Yes	5	Yes	5
44	Ramakumar Palla	209Y5A0157	Yes	Yes	5	Yes	5
45	Obula Reddy Pasam	209Y5A0158	Yes	Yes	4	Yes	4
46	Ajay Kumar Pesala	209Y5A0159	Yes	Yes	5	Yes	5
47	Madhusudhana Peyala	209Y5A0160	Yes	Yes	5	Yes	5
48	Lakshmana Pillagowla	209Y5A0161	Yes	Yes	5	Yes	5
49	Jaya Simha Santolla	209Y5A0170	Yes	Yes	5	Yes	5
50	Sohail Shaik	209Y5A0174	Yes	Yes	4	Yes	4
51	Parthasarathi Reddy Thammireddy	209Y5A0176	Yes	Yes	4	Yes	5
52	Vinod Kumar Uppara	209Y5A0180	Yes	Yes	4	May be	4
53	Gayathri Vanthatipalli	209Y5A0181	Yes	Yes	5	Yes	5

54	Sai Kumar Velligaram	209Y5A0183	Yes	Yes	5	Yes	5
55	Jagan Mohan Reddy Vennapusa	209Y5A0184	Yes	Yes	5	Yes	5
56	Madhava Reddy Vundela	209Y5A0186	Yes	Yes	5	Yes	5
57	Hemadri Yatagiri	209Y5A0187	Yes	Yes	5	May be	5
58	Naga Mahendra Yerragorla	209Y5A0189	Yes	Yes	4	May be	5

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