

A Relational MySQL Database for Rupture-to-Rafters Simulations

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Abstract

Rupture-to-rafter simulations have been a major thrust area and an end goal for SCEC. Several researchers/research groups have performed end-to-end simulations in the last couple of decades. Unfortunately, much of this data is housed in individual desktops, especially the results from the structural simulations, not easily accessible to the SCEC community. To overcome this research need, we have created a prototype relational database using MySQL and have populated it with one of SCEC's earliest attempts at end-to-end simulations, a close recreation of the 1857 magnitude 7.9 earthquake on the San Andreas fault. It is hoped that this database will organically grow with the inclusion of other SCEC simulations of the kind (e.g., the great ShakeOut scenario earthquake). Such an expansive open database can be mined by various stakeholders including emergency managers, city governments, insurance companies, etc, toward a diverse range of applications.

1. Database description

The rupture-to-rafter simulation database comprises of 39 tables. These include a list of scenario earthquakes, a list of analysis sites/stations, three-component ground motion (ground acceleration, velocity, and displacement time histories) at each of these sites, a list of buildings, and the time-histories and maxims of various building response quantities. The tables corresponding to the structural response are designed to handle output from the structural analysis program FRAME3D. The database is easily expandable to accept output data files from other structural analysis programs such as the NSF-supported OpenSEES program, and commercial programs such as PERFORM3D, SAP2000, and ETABS. All tables are adequately linked and cross-referenced making the database searchable and amenable to selective data extraction using simple SQL statements.

Figure 1: Screenshot of the MySQL database showing the list of tables, a simple SQL statement to pull all the references included in the database and a view of the "references" table.

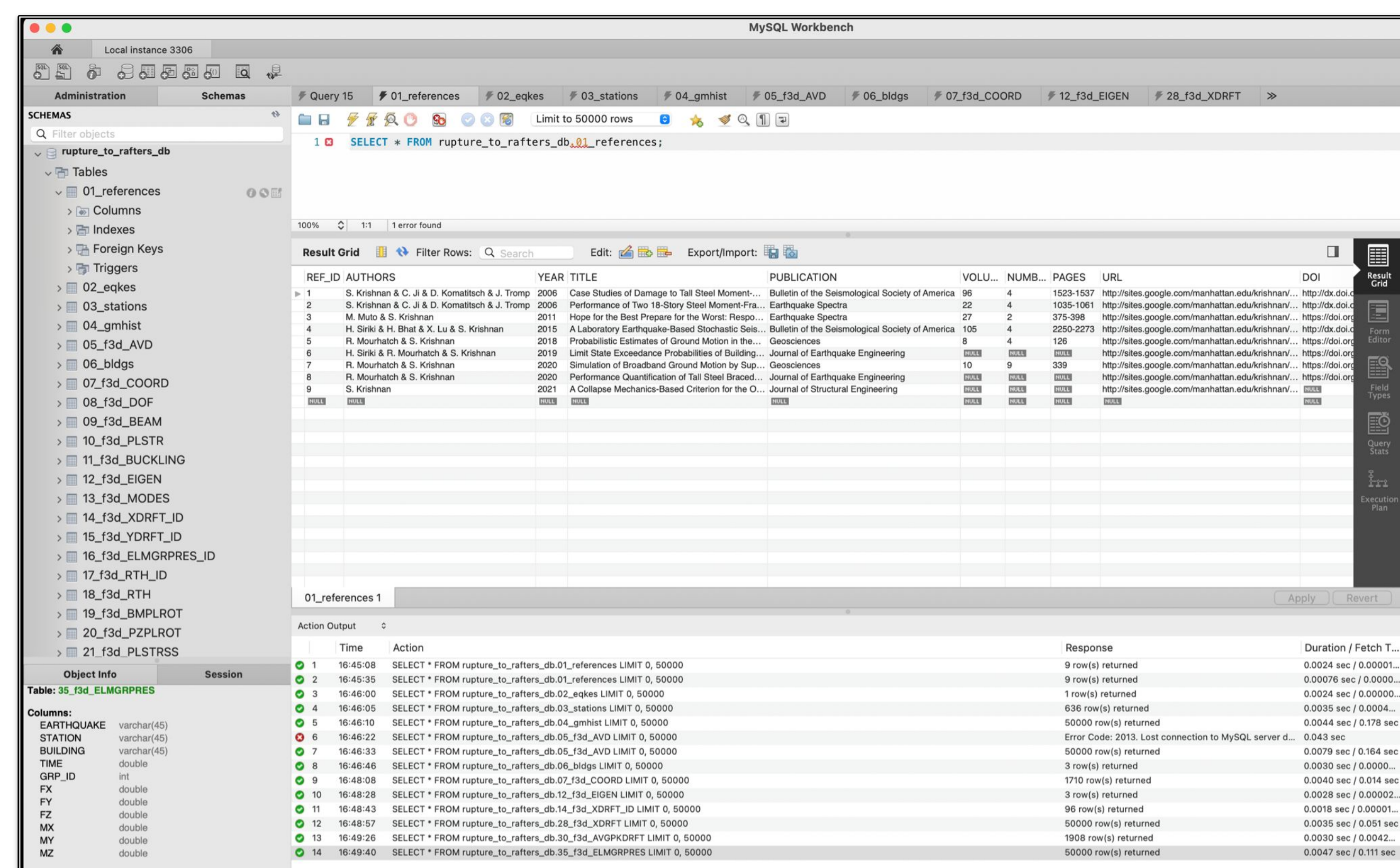


Figure 2: Screenshot of the earthquake list in the rupture-to-rafters MySQL database. It is populated with just the 1857-like San Andreas earthquake simulation at this time, but will be expanded to include other scenario earthquake simulations such as the ShakeOut scenario.

EARTHQUAKE	MAGNITU...	SYNTH_OR_R...	UNITS	PUB_REF_1	PUB_REF...	PUB_REF...	PUB_REF...
SAFDEN_rup1_NtoS	7.9	SYNTH	SI(m-s)	1	2	9	NULL

Figure 3: Table showing ground motion (three components of acceleration, velocity, and displacement) histories at station T03411L190 in the 1857-like San Andreas fault earthquake simulation.

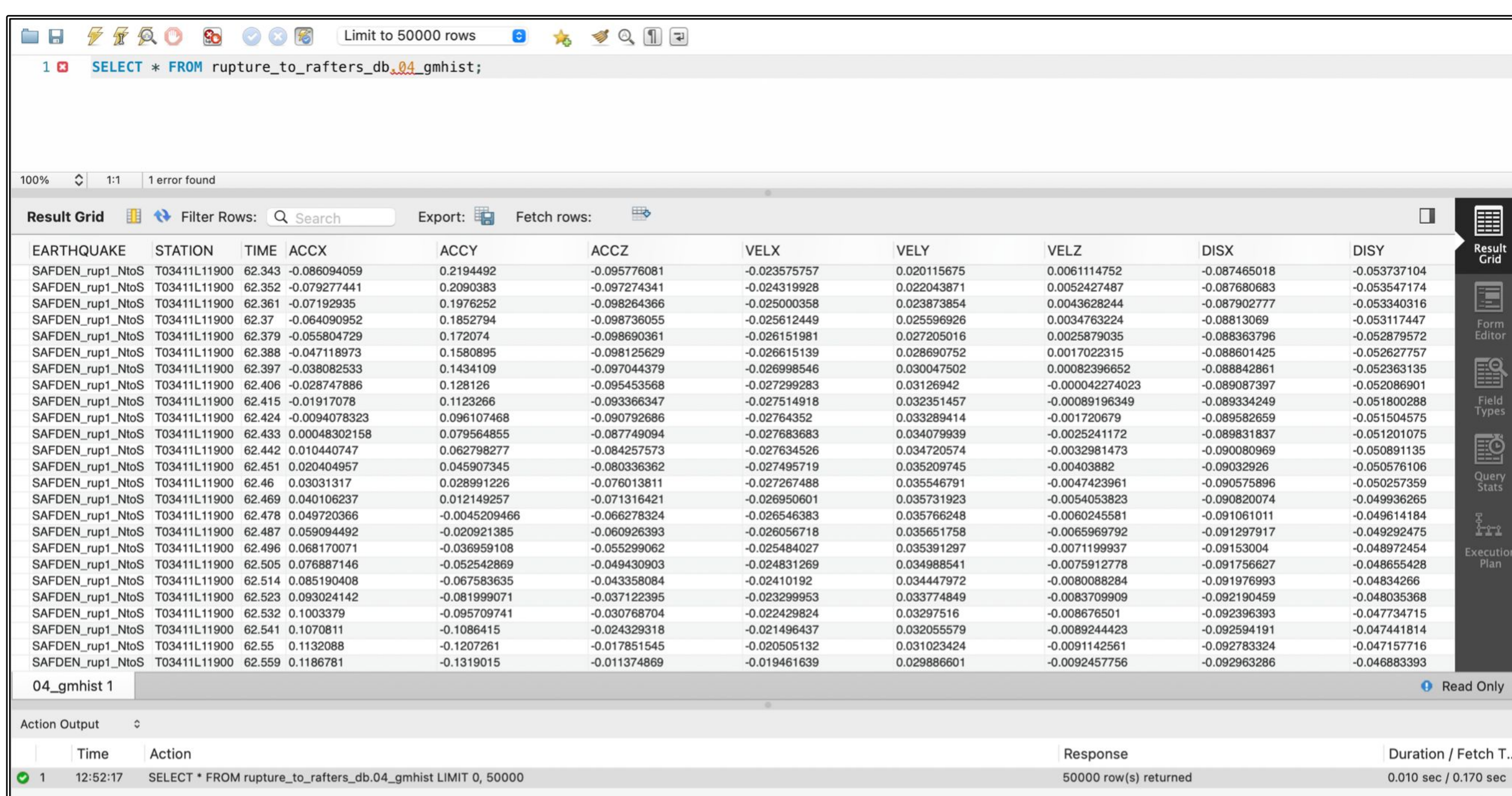


Figure 4: Table of stations with latitude and longitude coordinates.

STATION	LATITU...	LONGITU...
T03320L11726	33.625	117.812
T03320L11727	33.625	117.844
T03320L11728	33.625	117.875
T03320L11729	33.625	117.906
T03320L11730	33.625	117.938
T03320L11731	33.625	117.969
T03321L11724	33.6562	117.781
T03321L11725	33.6562	117.812
T03321L11726	33.6562	117.844
T03321L11727	33.6562	117.875
T03321L11728	33.6562	117.906
T03321L11729	33.6562	117.938
T03321L11730	33.6562	117.969
T03321L11731	33.6562	118
T03322L11724	33.6875	117.75
T03322L11725	33.6875	117.781
T03322L11726	33.6875	117.812
T03322L11727	33.6875	117.844
T03322L11728	33.6875	117.875
T03322L11729	33.6875	117.906
T03322L11730	33.6875	117.938
T03322L11731	33.6875	117.969
T03322L11800	33.6875	118
T03322L11801	33.6875	118.031

Figure 5: Table of building models included in the rupture-to-rafter simulations database.

BUILDING	UNITS	PUB_REF_1	PUB_REF...	PUB_REF...	PUB_REF...	PUB_REF...
Canoga_preNorthridge_MF_18story_exist_EX	US (K-in-s)	9	1	2	3	6
Canoga_preNorthridge_MF_18story_optim_OG	US (K-in-s)	9	1	2	3	6
Canoga_preNorthridge_MF_18story_optim_OU	US (K-in-s)	9	1	2	3	6

Figure 6: Table for the natural periods of the building models included in the rupture-to-rafter simulations database.

BUILDING	T01	T02	T03	T04	T05	T06	T07	T08	T09	T10
Canoga_preNorthridge_MF_18story_exist_EX	4.5422	4.2817	2.7033	1.5942	1.5812	1.0883	0.9516	0.3657	0.3576	
Canoga_preNorthridge_MF_18story_optim_OG	3.7074	3.5784	2.2323	1.6063	1.252	1.0763	0.7533	0.6971	0.3657	
Canoga_preNorthridge_MF_18story_optim_OU	4.0025	3.8441	2.4156	1.3218	1.2778	0.9627	0.7765	0.7042	0.3657	

Figure 7: Building model geometry (nodal coordinates, attachment point coordinates, etc.) stored in a linked table.

BUILDING	NODE	X	Y	Z	ATTPT1...	ATTPT2...	ATTPT3...	ATTPT4...	ATTPT5...	ATTPT6...	ATTPT7...	ATTPT8...	ATTPT9...	ATTPT10...	
Canoga_preNorthridge_MF_18story_exist_EX	1	0	1400	0	1400	0	0	1400	0	0	1400	0	0	1400	0
Canoga_preNorthridge_MF_18story_optim_OG	1	0	1026	0	1026	0	0	1026	0	0	1026	0	0	1026	0
Canoga_preNorthridge_MF_18story_optim_OU	1	0	700	0	700	0	0	700	0	0	700	0	0	700	0

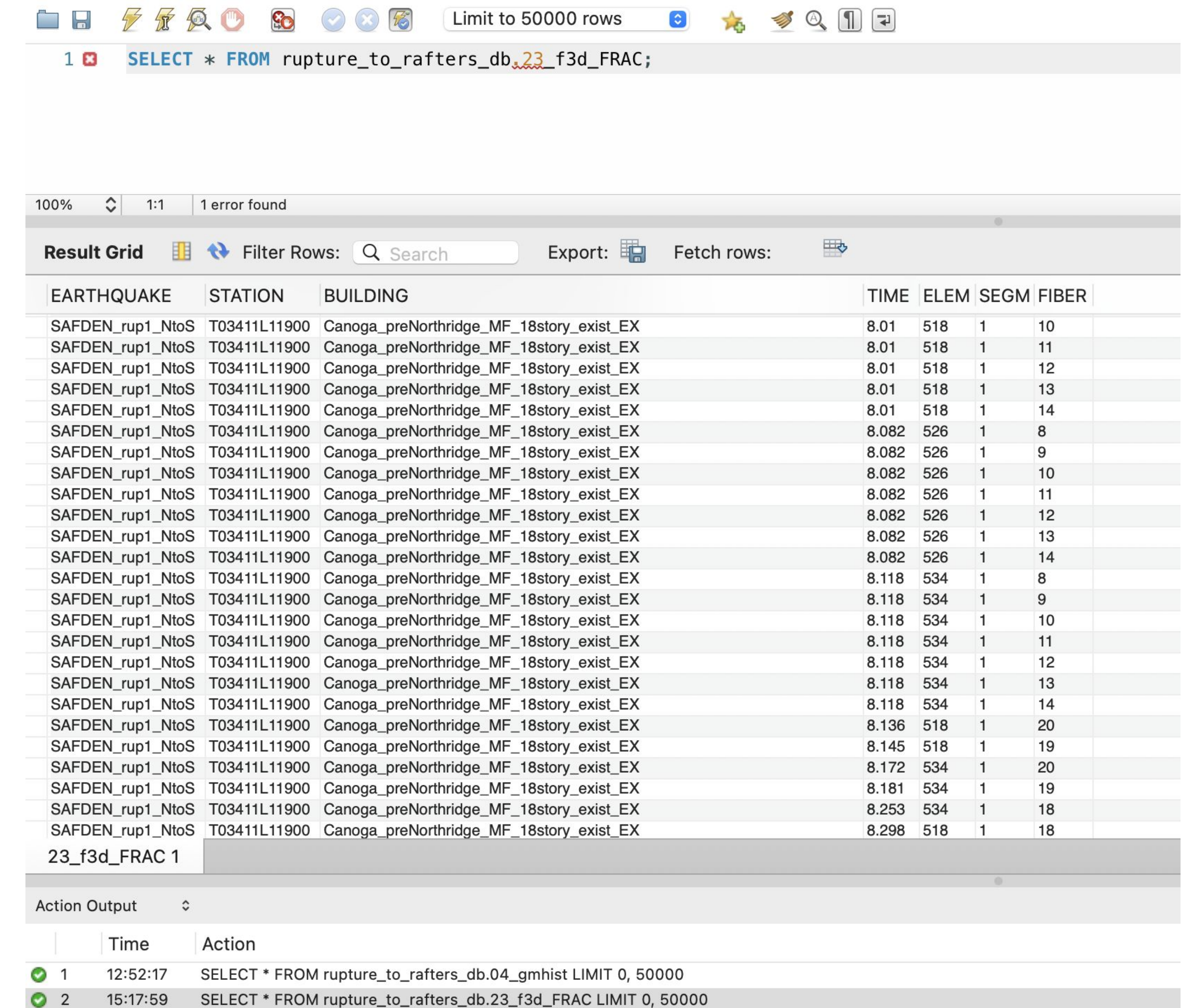
2. Concluding Remarks

At the 2021 PEER International Pacific Rim Forum held in June, the most pressing research need identified was the creation, development, and curation of an open database for rupture-to-rafter simulations. The database showcased here may be expanded or emulated by PEER for its rupture-to-rafter simulation database initiative. The idea of sharing this in poster form at the SCEC meeting is to generate discussion and suggestions for how SCEC researchers may help advance this overdue research need.

Figure 8: Table showing the lateral drift over the height of one of the building models hypothetically located at station T03411L1900 in the 1857-like San Andreas fault earthquake scenario. Lateral drifts are key engineering demand parameters that are indicative of structural safety and stability.

EARTHQUAKE	STATION	BUILDING	NUMB...	XDRIFT
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	1	0.016161
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	2	0.035962
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	3	0.481014
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	4	0.523782
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	5	0.519808
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	6	0.49359
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	7	0.106282
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	8	0.090705
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	9	0.07859
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	10	0.062115
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	11	0.043526
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	12	0.033013
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	13	0.02891
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	14	0.027179
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	15	0.026154
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	16	0.025705
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	17	0.025053
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	18	0.014783
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	19	0.031338
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	20	0.367897
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	21	0.40516
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	22	0.399038
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	23	0.384808
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	24	0.082769
SAFDEN_rup1_NtoS	T03411L1900	Canoga_preNorthridge_MF_18story_exist_EX	25	0.066519

Figure 9: The database stores highly granular damage data in the model buildings. Here is a table storing the precise time and location of fractures in the pre-Northridge moment connections of the steel building hypothetically located at station T03411L1900 in the 1857-like San Andreas fault earthquake scenario.



The database is downloadable from:
<https://sites.google.com/manhattan.edu/krishnan/home/software-data>