Ongoing Development Work
Multi-Site Damage Solution

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For

LexTech, Inc.

AFGROW Workshop

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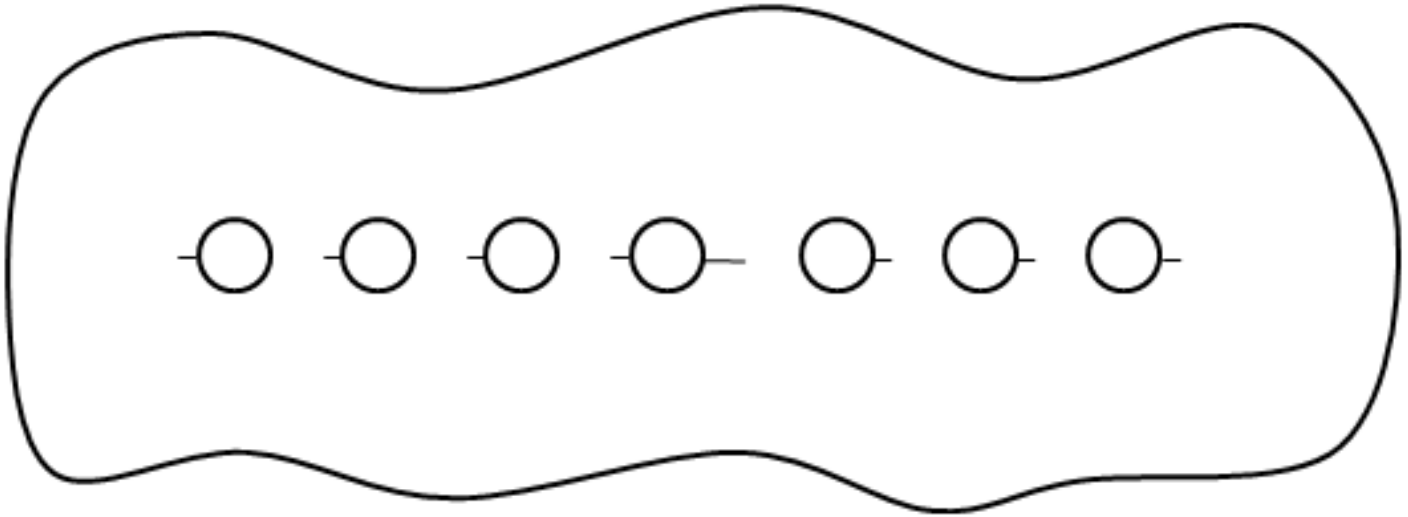
Multi-Site Damage Scenario



Single, primary crack with secondary cracks at each hole in a row of holes in an infinite plate

FEM Status

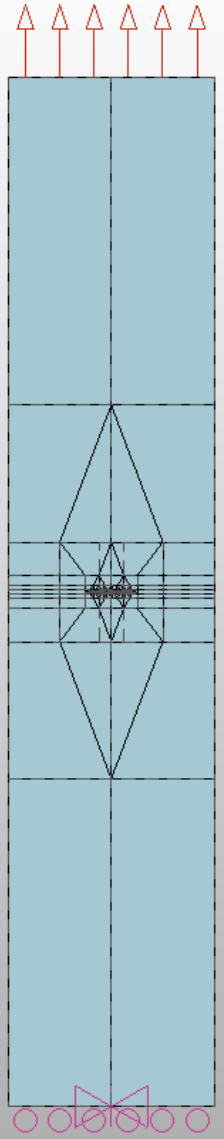
Initial Geometric Parameters

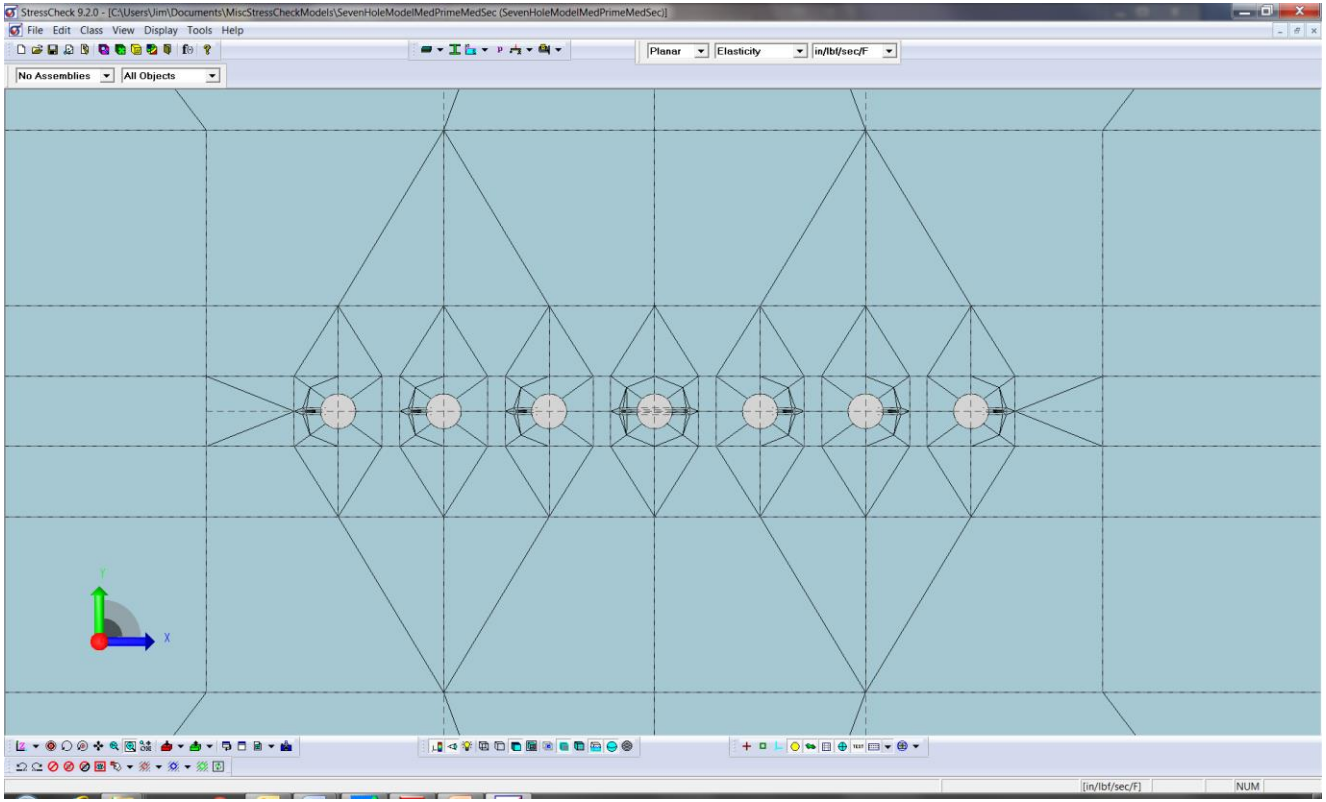
D=0.25, W=25, Hole Spacing: 3, 4, 6
Crack lengths: 0.005 < C < ~75% ligament

Load Cases

Axial, Bearing

FEM Details/BCs





Sample FEM Results

Hole Spacing 4D — Axial

S(remote)	W/D	D	W	H	C1	C2	K1	K2	B1	B2	KHL1	Beta	KHL2	Beta	KHL3	Beta	KHR1	Beta	KHR2	Beta	KHR3	Beta
1	100	0.25	25	125	0.05	0.005	0.7595	0.4081	1.916319	3.256167	0.3904	3.114941	0.3903	3.114143	0.3908	3.118133	0.3909	3.118931	0.3903	3.114143	0.3903	3.114143
1	100	0.25	25	125	0.05	0.01	0.7616	0.5361	1.921618	3.02462	0.5122	2.889779	0.5126	2.892036	0.5133	2.895985	0.5134	2.896549	0.5126	2.892036	0.5122	2.889779
1	100	0.25	25	125	0.05	0.02	0.7682	0.6666	1.93827	2.659349	0.6354	2.534879	0.637	2.541262	0.6382	2.54605	0.6383	2.546449	0.637	2.541262	0.6355	2.535278
1	100	0.25	25	125	0.05	0.03	0.7769	0.7326	1.960222	2.386335	0.6968	2.269722	0.6998	2.279494	0.7013	2.28438	0.7014	2.284705	0.6998	2.279494	0.6969	2.270047
1	100	0.25	25	125	0.05	0.04	0.7867	0.7716	1.984948	2.176643	0.7326	2.066626	0.7369	2.078757	0.7387	2.083834	0.7389	2.084398	0.737	2.079039	0.7326	2.066626
1	100	0.25	25	125	0.05	0.05	0.7973	0.7973	2.011694	2.011694	0.7559	1.907236	0.7617	1.92187	0.7639	1.927421	0.7638	1.927169	0.7617	1.92187	0.7559	1.907236

S(remote)	W/D	D	W	H	C1	C2	K1	K2	B1	B2	KHL1	Beta	KHL2	Beta	KHL3	Beta	KHR1	Beta	KHR2	Beta	KHR3	Beta
1	100	0.25	25	125	0.1	0.05	0.8574	0.8466	1.529708	2.136084	0.7562	1.907993	0.7624	1.923636	0.766	1.93272	0.767	1.935243	0.7625	1.923889	0.7563	1.908245
1	100	0.25	25	125	0.1	0.06	0.8688	0.8662	1.550047	1.995114	0.7727	1.779756	0.7804	1.797491	0.7845	1.806934	0.7854	1.809007	0.7806	1.797952	0.7729	1.780216
1	100	0.25	25	125	0.1	0.07	0.8805	0.8809	1.570921	1.878463	0.7855	1.675029	0.7947	1.694647	0.799	1.703817	0.7998	1.705522	0.7948	1.69486	0.7857	1.675455
1	100	0.25	25	125	0.1	0.08	0.8922	0.8938	1.591796	1.782873	0.796	1.58779	0.8065	1.608735	0.8115	1.618708	0.812	1.619706	0.8067	1.609134	0.7961	1.58799
1	100	0.25	25	125	0.1	0.09	0.9038	0.9033	1.612491	1.698775	0.8049	1.513721	0.8169	1.536288	0.8222	1.546256	0.8224	1.546632	0.8169	1.536288	0.8049	1.513721
1	100	0.25	25	125	0.1	0.1	0.9157	0.915	1.633722	1.632474	0.813	1.450493	0.827	1.475471	0.835	1.489744	0.835	1.489744	0.825	1.471902	0.813	1.450493

S(remote)	W/D	D	W	H	C1	C2	K1	K2	B1	B2	KHL1	Beta	KHL2	Beta	KHL3	Beta	KHR1	Beta	KHR2	Beta	KHR3	Beta
1	100	0.25	25	125	0.25	0.05	0.9795	0.9831	1.105247	2.480492	0.7575	1.911273	0.765	1.930196	0.7739	1.952652	0.783	1.975613	0.7663	1.933476	0.758	1.912534
1	100	0.25	25	125	0.25	0.1	1.036	1.056	1.169001	1.884035	0.8176	1.4587	0.833	1.486175	0.8452	1.507942	0.8541	1.52382	0.8343	1.488495	0.818	1.459414
1	100	0.25	25	125	0.25	0.15	1.094	1.105	1.234447	1.609688	0.8633	1.257596	0.888	1.293577	0.9035	1.316157	0.9105	1.326354	0.889	1.295034	0.8637	1.258179
1	100	0.25	25	125	0.25	0.2	1.153	1.156	1.301021	1.458371	0.9113	1.149665	0.9471	1.194829	0.9661	1.218799	0.9703	1.224098	0.9478	1.195713	0.9115	1.149918
1	100	0.25	25	125	0.25	0.225	1.183	1.184	1.334873	1.408269	0.9364	1.113769	0.9788	1.1642	0.9998	1.189178	1.002	1.191795	0.9792	1.164676	0.9366	1.114007
1	100	0.25	25	125	0.25	0.25	1.214	1.214	1.369852	1.369852	0.9619	1.085388	1.012	1.14192	1.035	1.167872	1.035	1.167872	1.012	1.14192	0.9619	1.085388

S(remote)	W/D	D	W	H	C1	C2	K1	K2	B1	B2	KHL1	Beta	KHL2	Beta	KHL3	Beta	KHR1	Beta	KHR2	Beta	KHR3	Beta
1	100	0.25	25	125	0.5	0.05	1.209	1.175	0.964642	2.964681	0.7604	1.91859	0.7704	1.943821	0.7895	1.992013	0.8481	2.139869	0.7773	1.961231	0.7626	1.924141
1	100	0.25	25	125	0.5	0.1	1.271	1.257	1.014111	2.242644	0.8215	1.465658	0.8403	1.499199	0.865	1.543267	0.9267	1.653348	0.8483	1.513472	0.824	1.470118
1	100	0.25	25	125	0.5	0.2	1.408	1.357	1.123421	1.711945	0.9168	1.156604	0.9572	1.207571	0.9925	1.252105	1.05	1.324645	0.966	1.218673	0.9196	1.160136
1	100	0.25	25	125	0.5	0.3	1.552	1.48	1.238317	1.524496	1.022	1.052726	1.097	1.129981	1.145	1.179424	1.193	1.228867	1.106	1.139251	1.024	1.054786
1	100	0.25	25	125	0.5	0.4	1.71	1.646	1.364383	1.468334	1.136	1.013382	1.272	1.134703	1.337	1.192687	1.367	1.219449	1.278	1.140055	1.138	1.015167
1	100	0.25	25	125	0.5	0.5	1.895	1.895	1.511991	1.511991	1.265	1.009324	1.516	1.209593	1.611	1.285392	1.611	1.285392	1.516	1.209593	1.265	1.009324

Approach/Issues

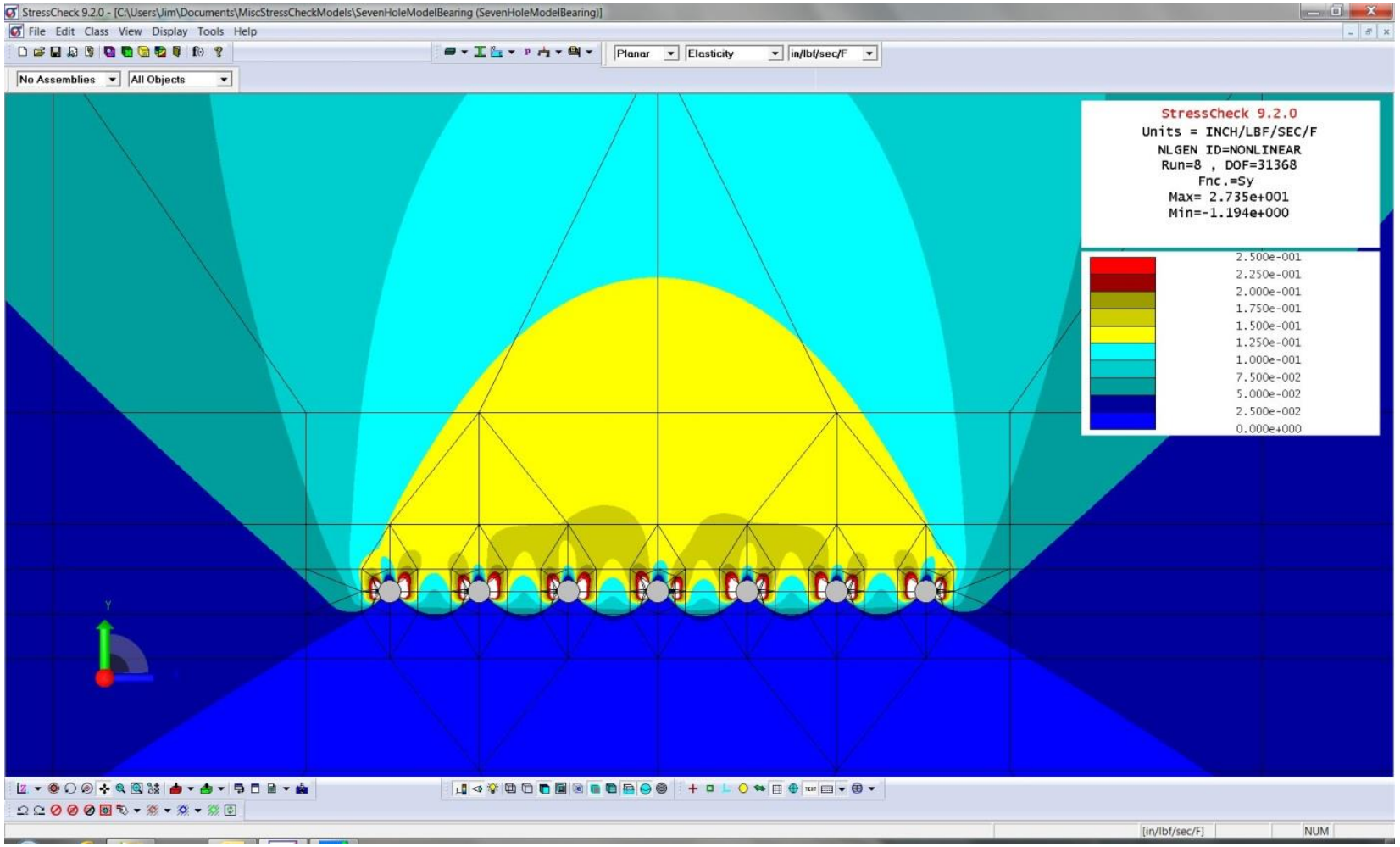
- Looking for trends
- Can the solution be compounded?
- Do the solutions converge to the left & right of the primary hole?
- Bearing loading is assumed constant at each hole
- Bearing loads create bypass stress fields around adjacent holes

Compounding?

Compounding appears to be possible for the axial/bearing loading case, respectively

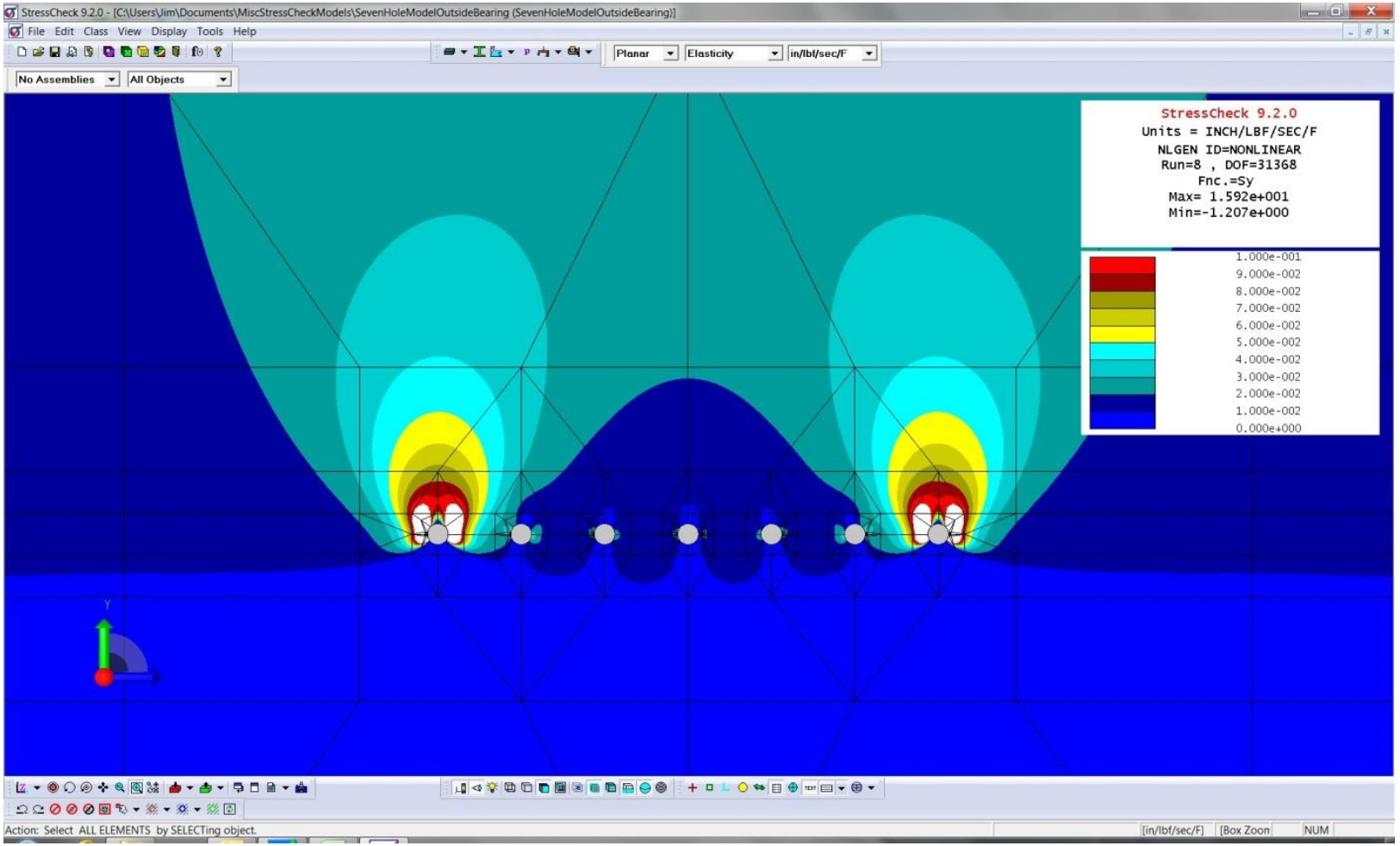
The bearing load case will be complicated by the bypass stress issue, but the results to date are encouraging

Bearing/Bypass Issue



Bearing load at each hole

Bearing/Bypass Issue



Bearing load at the outside holes

Status

Initial FEM cases for axial and bearing load cases are complete for all three hole spacings (3,4, & 6)

Work has started to test compounding methods

Completion date is still unknown, but good progress is being made at AFRL