

Experimental data:

Table 1. Water and sand flow rates for the tests of sand particles migration in sand–quartz–filled bed

time (s)	0.095 MPa		0.17 MPa		0.23 MPa		0.25 MPa		0.377 MPa	
	Sand flow rate (cm ³ /s)	Water flow rate (cm ³ /s)	Sand flow rate (cm ³ /s)	Water flow rate (cm ³ /s)	Sand flow rate (cm ³ /s)	Water flow rate (cm ³ /s)	Sand flow rate (cm ³ /s)	Water flow rate (cm ³ /s)	Sand flow rate (cm ³ /s)	Water flow rate (cm ³ /s)
0	0	0	0	0	0	0	0	0	0	0
3	2.26337	8.97119	2.6749	11.8642	3.90947	46.69136	4.52675	65.69959	8.02469	90.30864
6	3.68486	18.29218	4.32099	26.15226	5.04115	62.38272	5.96708	69.08025	8.12757	83.37243
9	4.27526	24.19616	4.95084	39.84499	5.36236	61.19204	6.0608	76.11797	7.40741	82.81481
12	4.26955	22.64403	4.60476	38.46296	4.93827	60.66049	5.67728	79.63683	7.02416	83.59671
15	4.03292	25.1572	4.29355	37.65926	4.74005	60.00988	5.52948	68.0214	6.13169	107.57942
18	3.80658	23.36694	4.08722	37.12346	4.31916	54.13306	4.99141	60.61797	5.41838	96.738
21	3.52734	23.61905	3.76249	38.03469	4.02974	48.42269	4.5429	54.41858	4.82608	90.28395
24	3.3179	30.01132	3.62654	36.70885	3.88001	45.59105	4.15037	48.25412	4.28643	79.83436
27	3.36915	34.89803	3.54367	35.22405	3.65135	43.99817	3.73075	46.26612	3.8243	74.26246
30	3.35391	32.79877	3.37449	38.62881	3.40682	41.62675	3.43621	43.19588	3.45679	67.65985

Table 2. Mass of SFO and porosity for the tests of sand particles migration in sand–quartz–filled bed

time (s)	0.095 MPa		0.17 MPa		0.23 MPa		0.25 MPa		0.377 MPa	
	Mass of SFO	Porosity	Mass of loss sand	Porosity	Mass of loss sand	Porosity	Mass of loss sand	Porosity	Mass of loss sand	Porosity
0	0	30.94	0	30.94	0	30.94	0	30.94	0	30.94
3	17.79012	32.1388	21.02469	32.35723	30.7284	33.01252	35.58025	33.34017	63.07407	35.19683
6	57.92593	34.84917	67.92593	35.52447	79.24691	36.28898	93.80247	37.27191	127.76543	39.56543
9	100.8107	37.74518	116.74074	38.82093	126.44444	39.47622	142.91358	40.58838	174.66667	42.73267
12	134.23457	40.00229	144.77366	40.714	155.25926	41.42209	178.49383	42.99112	220.83951	45.85072
15	158.49383	41.64052	168.73663	42.33221	186.28395	43.51718	217.30864	45.61228	240.97531	47.21049
18	179.51852	43.06032	192.75309	43.95405	203.69136	44.69271	235.39506	46.83366	255.53086	48.19343
21	194.07407	44.04325	207.01235	44.91697	221.71605	45.90991	249.95062	47.81659	265.53086	48.86873
24	208.62963	45.02619	228.03704	46.33677	243.97531	47.41308	260.97531	48.56109	269.53086	49.13885
27	238.33333	47.03208	250.67901	47.86578	258.2963	48.38018	263.91358	48.75951	270.53086	49.20638
30	263.61728	48.7395	265.23457	48.84872	267.77601	49.02034	270.08642	49.17636	271.7037	49.28558

Table 3. Change rate of porosity for the tests of sand particles migration in sand–quartz–filled bed

time (s)	Change rate of porosity (min ⁻¹)				
	0.095 MPa	0.17 MPa	0.23 MPa	0.25 MPa	0.377 MPa
0	0	0	0	0	0
3	0.23976	0.28345	0.4145	0.48003	0.85137
6	0.54207	0.63345	0.65529	0.78635	0.87372
9	0.5792	0.65929	0.63745	0.66329	0.63345
12	0.45142	0.37861	0.38917	0.48055	0.62361
15	0.32765	0.32364	0.41902	0.52423	0.27195
18	0.28396	0.32437	0.2351	0.24428	0.19659
21	0.19659	0.19259	0.24344	0.19659	0.13506
24	0.19659	0.28396	0.30063	0.1489	0.05402
27	0.40118	0.3058	0.19342	0.03968	0.01351
30	0.34148	0.19659	0.12803	0.08337	0.01584

Table .4 Sand flow rate for the tests of water–sand mixed fluid migration

time (s)	Sand flow rate (cm ³ /s)									
	1.14	1.66	2.17	2.69	3.20	3.72	4.32	4.75	5.26	5.78
0	0	0	0	0	0	0	0	0	0	0
3	0.41152	0.20576	0.20576	0.20576	0.20576	1.44033	1.44033	1.44033	1.23457	1.02881
6	0.92593	0.5144	1.85185	1.13169	0.41152	1.33745	2.6749	2.77778	3.29218	3.1893
9	1.23457	1.09739	1.98903	1.78326	1.44033	2.1262	3.15501	3.42936	4.18381	4.04664
12	1.33745	1.13169	2.10905	2.00617	1.90329	2.52058	3.13786	3.7037	4.57819	4.52675
15	1.39918	1.27572	2.05761	2.13992	2.13992	2.59259	3.29218	3.86831	4.81481	4.77366

18	1.44033	1.37174	2.1262	2.1262	2.36626	2.81207	3.42936	4.01235	4.93827	5.00686
21	1.44033	1.44033	2.1458	2.17519	2.52792	2.93945	3.52734	4.17402	5.02646	5.20282
24	1.44033	1.44033	2.13477	2.21193	2.52058	3.0607	3.47222	4.29527	5.11831	5.37551
27	1.44033	1.48605	2.08048	2.26337	2.60631	3.0407	3.58939	4.41244	5.18976	5.48697
30	1.44033	1.52263	2.09877	2.22222	2.69547	3.16872	3.66255	4.50617	5.22634	5.57613
33	1.45903	1.55256	2.11373	2.26337	2.76842	3.27348	3.74111	4.58287	5.25627	5.63038
36	1.44033	1.52606	2.1262	2.29767	2.76063	3.36077	3.68656	4.62963	5.29835	5.70988
39	1.45616	1.55112	2.1051	2.35834	2.81735	3.35549	3.75119	4.6692	5.31814	5.76132
42	1.45503	1.5726	2.1311	2.35156	2.88066	3.42446	3.77719	4.70312	5.3351	5.80541
45	1.45405	1.5775	2.15364	2.40055	2.92181	3.47051	3.79973	4.73251	5.34979	5.84362
48	1.45319	1.56893	2.18621	2.44342	2.89352	3.52366	3.75514	4.75823	5.37551	5.88992
51	1.45243	1.58557	2.16655	2.48124	2.94118	3.49794	3.78843	4.79303	5.41031	5.93077
54	1.45176	1.58893	2.18336	2.46914	2.96068	3.5208	3.80658	4.82396	5.45267	5.95565
57	1.45116	1.6136	2.1984	2.49079	2.99978	3.54126	3.82283	4.84081	5.47975	5.96708
60	1.44033	1.60494	2.21193	2.51029	2.97325	3.54938	3.78601	4.85597	5.50412	5.97737
63	1.44033	1.62649	2.19479	2.52792	3.00803	3.51754	3.80169	4.86968	5.52616	6.00627
66	1.44968	1.63674	2.20726	2.5159	3.0303	3.53535	3.81594	4.88215	5.5462	6.02319
69	1.45822	1.65504	2.21864	2.5407	3.05064	3.56057	3.82895	4.89354	5.5645	6.03865
72	1.46605	1.64609	2.23765	2.56344	3.04355	3.58368	3.79801	4.92112	5.58128	--
75	1.48148	1.66255	2.22222	2.57613	3.06996	3.56379	3.8107	4.95473	5.59671	
78	1.49573	1.66983	2.23172	2.57202	3.08642	3.585	3.83824	4.96993	5.61887	
81	1.50892	1.68419	2.24051	2.59107	3.10928	3.61225	3.87136	4.984		
84	1.51382	1.67549	2.25603	2.60876	3.09377	3.63022	3.85802	5.00441		
87	1.52547	1.68157	2.24209	2.63233	3.1148	3.61147	3.87399	5.02341		
90	1.52949	1.6941	2.25652	2.62689	3.12757	3.62826	3.88889	--		
93	1.53989	1.69919	2.26337	2.64171	3.13952	3.64397	3.90283			
96	1.54964	1.69753	2.27623	2.66204	3.125	3.66512	3.89017			
99	1.55256	1.70221	2.26961	2.6749	3.14254	3.64135				
102	1.56137	1.70661	2.27548	2.66885	3.15299	3.66134				
105	1.56966	1.71664	2.28689	2.68078	3.15697					
108	1.5775	1.70896	2.29767	2.69204	3.14358					
111	1.58492	1.71839	2.29118	2.7027	3.15315					
114	1.59194	1.7219	2.30128	2.69656	3.16223					
117	1.59861	1.73051	2.31613	2.71183						
120	1.60494	1.72325	2.33025	2.72634						
123	1.60594	1.72639	2.3236	2.74014						
126	1.6118	1.73427	2.33196	2.75328						
129	1.61738	1.73701	2.33994	2.74667						
132	1.62271	1.73027	2.35223							
135	1.6278	1.73297	2.34568							
138	1.6282	1.73555	2.35284							
141	1.63296	1.73803	2.35969							
144	1.63752	1.73611	2.36626							
147	1.64189	1.74267	2.35576							
150	1.64609	1.74486	2.36214							
153	1.65013	1.74695	2.37231							
156	1.654	1.74501	2.37813							
159	1.65774	1.74703	2.37596							

162	1.65752	1.75278
165	1.66105	1.75832
168	1.66446	1.75265
171	1.66775	1.758
174	1.66738	1.75961
177	1.6705	1.76466
180	1.67353	1.75926
183	1.67308	1.76415
186	1.67596	1.76888
189	1.67875	1.7702
192	1.67824	1.76505
195	1.68091	1.76638
198	1.6835	1.77079
201	1.68294	1.77508
204	1.68543	1.77318
207	1.68784	1.7773
210	1.68724	1.78424
213	1.68956	--
216	1.69182	--
219	1.69401	
222	1.69614	
225	1.69822	
228	1.70024	
231	1.69954	
234	1.70149	
237	1.70339	
240	1.70525	
243	1.70452	
246	1.70882	
249	1.71055	
252	1.71223	
255	1.71387	

Table 5. Water flow rate for the tests of water–sand mixed fluid migration

time (s)	Water flow rate (cm ³ /s)									
	1.14	1.66	2.17	2.69	3.20	3.72	4.32	4.75	5.26	5.78
0	0	0	0	0	0	0	0	0	0	0
3	1.58848	0.46091	1.12757	0.79424	0.46091	0.893	3.22634	3.55967	1.09877	4.63786
6	1.07407	2.15226	1.81481	0.86831	0.58848	2.16255	3.3251	4.05556	0.70782	3.3107
9	0.87654	1.68038	1.89986	0.99451	0.893	2.42936	3.28944	3.45953	0.81619	3.06447
12	0.91255	1.61831	1.89095	1.32716	1.34671	2.64609	3.61214	3.12963	0.75514	2.38992
15	0.80082	1.52428	2.00905	1.52675	1.59342	2.94074	3.57449	2.59835	1.11852	2.42634
18	0.67078	1.40604	1.92936	1.70713	1.80041	2.91015	3.51509	2.54321	1.06173	2.5487
21	0.60729	1.36919	1.94944	1.77719	1.90065	2.9177	3.52028	2.54027	1.30688	2.55908
24	0.60134	1.393	1.94856	1.82973	2.14609	2.9393	3.65278	2.57973	1.42335	2.29115
27	0.59671	1.3658	1.95656	1.8107	2.2085	3.10745	3.66987	2.3283	1.55098	2.36488
30	0.593	1.3107	1.93457	1.94444	2.27119	3.13128	3.67078	2.32716	1.44033	2.39053

33	0.60157	1.29592	1.91657	1.94875	2.29218	3.15077	3.65282	2.29592	1.56192	2.43023
36	0.61523	1.33505	1.90158	1.98011	2.43381	3.19479	3.73011	2.31481	1.64609	2.26235
39	0.56948	1.32067	1.94619	2.00063	2.4647	3.28553	3.71035	2.17695	1.7075	2.31561
42	0.56878	1.28454	1.94033	2.07701	2.50029	3.28983	3.67519	2.20165	1.64109	2.36126
45	0.54595	1.28916	1.93525	2.11056	2.52263	3.28505	3.66694	2.20082	1.69465	2.40082
48	0.56764	1.30607	1.91795	2.13992	2.58565	3.28884	3.72402	2.22094	1.74949	2.27675
51	0.54757	1.29678	1.97071	2.14621	2.58824	3.34519	3.70177	2.10893	1.80537	2.30453
54	0.54824	1.31847	1.96479	2.19753	2.6134	3.33105	3.6749	2.12048	1.73251	2.32213
57	0.54884	1.29868	1.9595	2.21096	2.61425	3.31839	3.6684	2.14165	1.80095	2.34871
60	0.57634	1.3284	1.95473	2.22305	2.67675	3.30062	3.69733	2.14403	1.82922	2.27263
63	0.55967	1.32589	1.97982	2.23398	2.67451	3.32373	3.67451	2.06682	1.88654	2.29532
66	0.56547	1.33296	1.97456	2.27198	2.69697	3.32828	3.65376	2.08754	1.81743	2.32529
69	0.58526	1.33047	1.96976	2.27089	2.70299	3.32349	3.64931	2.09197	1.85579	2.33816
72	0.6034	1.35391	1.95679	2.28378	2.73422	3.30521	3.67421	2.12054	1.89095	--
75	0.58519	1.35078	1.99111	2.29053	2.74337	3.35621	3.6693	2.04527	1.90996	
78	0.59402	1.35581	1.98623	2.32542	2.74691	3.3509	3.66176	2.05571	1.97088	
81	0.60219	1.35284	1.98171	2.33486	2.75492	3.35071	3.6595	2.06539		
84	0.61714	1.36023	1.97016	2.34362	2.79909	3.35788	3.7015	2.07892		
87	0.60096	1.36441	1.99929	2.34469	2.79325	3.38853	3.68923	2.01107		
90	0.61495	1.36145	1.98793	2.38422	2.80576	3.38285	3.68889	--		
93	0.6214	1.36533	1.98394	2.4013	2.80672	3.38829	3.68857			
96	0.62744	1.37539	1.98418	2.40046	2.83333	3.38696	3.72441			
99	0.61915	1.3786	1.99302	2.41601	2.82716	3.41925				
102	0.62491	1.38163	1.99903	2.439	2.8274	3.40729				
105	0.63986	1.3786	1.99882	2.44303	2.83351					
108	0.64472	1.38363	1.98937	2.44684	2.85642					
111	0.6313	1.38071	2.00612	2.45045	2.84685					
114	0.63613	1.38337	2.01451	2.47011	2.84655					
117	0.64926	1.38061	2.00865	2.47621						
120	0.6534	1.39342	2.01142	2.482						
123	0.64609	1.39556	2.026	2.4875						
126	0.65011	1.39271	2.02518	2.50069						
129	0.65394	1.38702	2.03216	2.51689						
132	0.65759	1.39852	2.02656							
135	0.64627	1.39296	2.04691							
138	0.65441	1.39488	2.04571							
141	0.66492	1.39673	2.04457							
144	0.66804	1.40278	2.04347							
147	0.65743	1.40018	2.05241							
150	0.66058	1.40181	2.05119							
153	0.6636	1.40337	2.05253							
156	0.66651	1.40883	2.05136							
159	0.66302	1.4102	2.06429							
162	0.66964	1.40154								
165	0.67228	1.39925								
168	0.67482	1.40807								
171	0.66558	1.40575								
174	0.6717	1.40705								

177	0.67413	1.40483
180	0.67647	1.41296
183	0.67119	1.41071
186	0.6735	1.40854
189	0.67575	1.40969
192	0.68113	1.41204
195	0.67293	1.40798
198	0.67508	1.40597
201	0.68024	1.409
204	0.68222	1.4131
207	0.67448	1.41594
210	0.67942	1.41576
213	0.68133	--
216	0.68781	--
219	0.68042	
222	0.68224	
225	0.68401	
228	0.68573	
231	0.68142	
234	0.68313	
237	0.68479	
240	0.68642	
243	0.68231	
246	0.68549	
249	0.68704	
252	0.69253	
255	0.68613	

Table 6. Solid particle concentration for the tests of water–sand mixed fluid migration

time (s)	Water flow rate (cm ³ /s)									
	1.14	1.66	2.17	2.69	3.20	3.72	4.32	4.75	5.26	5.78
0	0	0	0	0	0	0	0	0	0	0
3	0.20576	0.30864	0.15432	0.41152	0.30864	0.61728	0.30864	0.28807	0.5291	0.18155
6	0.46296	0.1929	0.50505	0.56584	0.41152	0.38213	0.44582	0.4065	0.82305	0.49066
9	0.5848	0.39506	0.51146	0.64198	0.61728	0.46673	0.48957	0.49781	0.83676	0.56906
12	0.59442	0.41152	0.52726	0.60185	0.58563	0.48785	0.46487	0.54201	0.85841	0.65447
15	0.63599	0.45561	0.50597	0.58361	0.57319	0.46854	0.47944	0.59819	0.81149	0.66301
18	0.68226	0.49383	0.52427	0.55466	0.5679	0.49143	0.49383	0.61205	0.82305	0.66267
21	0.70342	0.51266	0.52397	0.55035	0.57082	0.50186	0.5005	0.62166	0.79365	0.6703
24	0.70547	0.50835	0.5228	0.54728	0.54012	0.51012	0.48733	0.62477	0.78242	0.70115
27	0.70707	0.52108	0.51535	0.55556	0.54131	0.49457	0.49446	0.65459	0.76991	0.69881
30	0.70836	0.5374	0.52036	0.53333	0.54271	0.50297	0.49944	0.65944	0.78395	0.69993
33	0.70806	0.54505	0.52446	0.53735	0.54705	0.50955	0.50597	0.66623	0.77092	0.69851
36	0.7007	0.53338	0.52788	0.53712	0.53146	0.51266	0.49706	0.66667	0.76296	0.71622
39	0.71886	0.54012	0.51961	0.54103	0.53338	0.50527	0.50274	0.68202	0.75696	0.71331
42	0.71895	0.55041	0.52343	0.531	0.53534	0.51003	0.50684	0.68114	0.76476	0.71087
45	0.72702	0.55029	0.5267	0.53214	0.53666	0.51373	0.50889	0.68257	0.75943	0.7088

48	0.7191	0.54571	0.53268	0.53311	0.52809	0.51723	0.50208	0.68178	0.75446	0.72121
51	0.72622	0.5501	0.52367	0.5362	0.53191	0.51116	0.50579	0.69444	0.7498	0.72016
54	0.72588	0.54651	0.52634	0.5291	0.53115	0.51385	0.5088	0.69465	0.75888	0.71947
57	0.72558	0.55407	0.52873	0.52976	0.53434	0.51625	0.51031	0.69328	0.75264	0.71756
60	0.71421	0.54714	0.53086	0.53034	0.52624	0.51816	0.50593	0.69371	0.75056	0.72453
63	0.72016	0.55091	0.52575	0.53086	0.52935	0.51416	0.50851	0.70204	0.7455	0.72351
66	0.71939	0.55115	0.52782	0.52547	0.5291	0.51508	0.51086	0.70048	0.75319	0.72147
69	0.7136	0.55436	0.52971	0.52804	0.53021	0.51722	0.51201	0.70053	0.7499	0.72088
72	0.70843	0.5487	0.53348	0.52885	0.52677	0.52021	0.50828	0.69886	0.74694	
75	0.71685	0.55173	0.52743	0.52934	0.52809	0.515	0.50945	0.70782	0.74556	
78	0.71575	0.55189	0.5291	0.52518	0.5291	0.51688	0.51177	0.7074	0.74032	
81	0.71475	0.55455	0.53065	0.52601	0.53021	0.51878	0.51407	0.70701		
84	0.71039	0.55192	0.53382	0.52677	0.525	0.51949	0.51035	0.7065		
87	0.71738	0.55206	0.52862	0.5289	0.52721	0.51592	0.51221	0.71411		
90	0.71323	0.55443	0.53164	0.52421	0.52712	0.5175	0.5132	0.71656		
93	0.71249	0.55447	0.5329	0.52384	0.52798	0.51818	0.51411			
96	0.7118	0.55242	0.53428	0.52583	0.52448	0.51972	0.51088			
99	0.7149	0.55252	0.53244	0.52543	0.52641	0.51573				
102	0.71417	0.55262	0.53234	0.5225	0.52722	0.51797				
105	0.71041	0.55461	0.53361	0.5232	0.527					
108	0.70988	0.5526	0.53596	0.52386	0.52393					
111	0.71515	0.55448	0.53317	0.52448	0.52553					
114	0.71449	0.55451	0.53322	0.52191	0.52627					
117	0.71117	0.55623	0.53555	0.52271						
120	0.71067	0.55291	0.53672	0.52346						
123	0.71311	0.55298	0.53421	0.52416						
126	0.71258	0.55462	0.5352	0.52404						
129	0.71209	0.55602	0.5352	0.52183						
132	0.71162	0.55301	0.53719							
135	0.71581	0.55439	0.53401							
138	0.71331	0.55441	0.53491							
141	0.71064	0.55444	0.53577							
144	0.71025	0.5531	0.5366							
147	0.71408	0.55449	0.53441							
150	0.71362	0.55451	0.53523							
153	0.71319	0.55453	0.53613							
156	0.71278	0.5533	0.53689							
159	0.71431	0.55334	0.5351							
162	0.71225	0.55568								
165	0.71188	0.55686								
168	0.71153	0.55451								
171	0.71475	0.55567								
174	0.71283	0.55567								
177	0.71248	0.55677								
180	0.71214	0.55458								
183	0.71369	0.55566								
186	0.71334	0.5567								
189	0.713	0.55669								

192	0.71131	0.55556
195	0.71411	0.55645
198	0.71378	0.55742
201	0.71215	0.55748
204	0.71186	0.55651
207	0.71448	0.55658
210	0.71292	0.55758
213	0.71263	
216	0.71096	
219	0.71344	
222	0.71315	
225	0.71287	
228	0.7126	
231	0.7138	
234	0.71353	
237	0.71326	
240	0.713	
243	0.71413	
246	0.7137	
249	0.71344	
252	0.71202	
255	0.71411	
