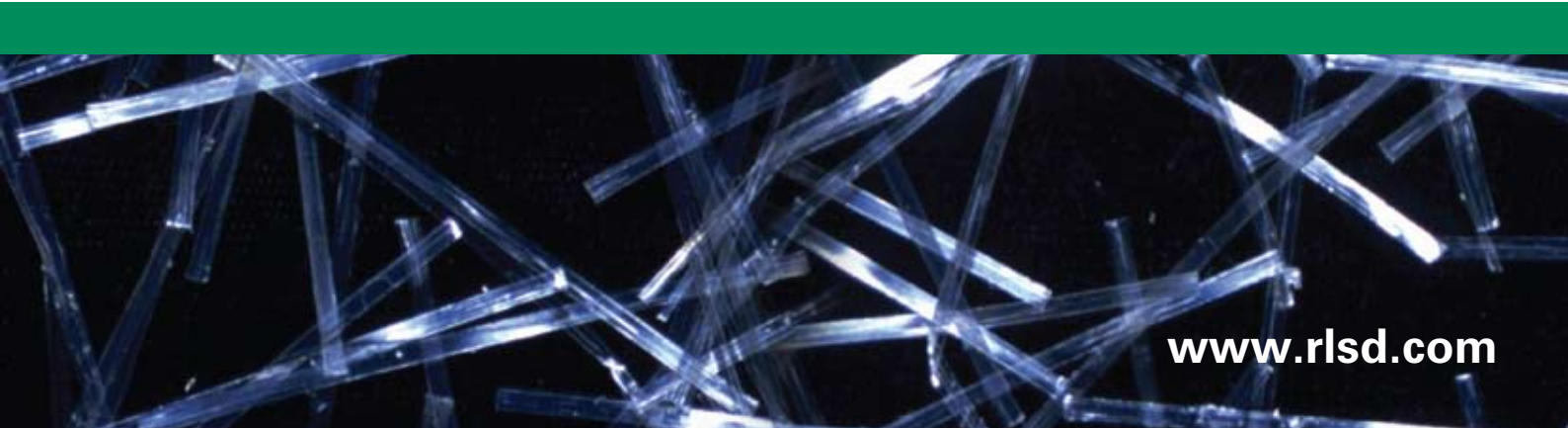


## Fibre Reinforced Composite Floor Slabs

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# Principle Benefits of Reinforcing Composite Steel

## Profile applications

Traditional composite floor slab design makes use of the decking profile to act as tensile reinforcement in the bottom of the slab. It also includes a layer of welded wire fabric in the top of the slab to control cracks, distribute loads around minor openings, resist horizontal shear forces, and to provide continuity over supports in the fire limit state. In many design cases synthetic macro fibre reinforcement can be used to replace the fabric layer and provide added benefits associated with simplicity and speed of construction.

## STRUX® 90/40 fibre reinforcement

STRUX® 90/40 synthetic structural fibres are marketed by Grace Construction Products Limited and have been used extensively in ground slabs for a number of years. The fibres are 40 mm long with an aspect ratio of 90, giving high strength with a high modulus. They have been designed to provide tight crack control whilst exhibiting excellent dispersion and pumpability characteristics. STRUX® 90/40 synthetic structural fibres offer a quick, easy and safe option for providing secondary reinforcement to a composite floor slab.

## Application

In collaboration with Grace Construction Products Limited, Richard Lees Steel Decking have researched and developed a system whereby much of the steel reinforcement in a composite floor slab can be replaced by fibres in the concrete mix. The development of this system required full scale testing of structural floor slabs and the results are therefore only applicable to the unique combinations of decking profile, fibre and fibre dosage tested. The test programme was developed in conjunction with the Steel Construction Institute (SCI) and the results processed by them to produce the design guidance given here.

Extensive testing, specified and verified by the Steel Construction Institute, has shown that STRUX® 90/40 can be an ideal replacement for steel fabric reinforcement in steel composite decks designed and supplied by Richard Lees Steel Decking Ltd. This testing has shown that, not only can the STRUX® 90/40 reinforcement meet the physical requirements for longitudinal shear and composite interaction in the floor plate, but also that with Holorex, a fire rating of up to two hours can be achieved.

## Advantages of STRUX® 90/40 over steel fabric reinforcement

STRUX® 90/40 reinforcement is premixed into the concrete so that when concrete is delivered to site it is immediately ready to be pumped and placed.

### Project time & cost

- No fabric to lift to level.
- No fabric storage space required.
- No fabric to fix, eliminating an entire step from the process.
- Productivity improvements.
- Reduction in clashes with the requirements of other contractors.

### Safety

- Risk reduction.
- Removal of all hazards associated with the installation of fabric.
- Removal of a trip hazard from the floor area prior to and during concreting.

### Flexibility & ease of application

- Improved logistics on site.
- Easier to maintain a clean and clear area for concrete placement.
- Reduction in pre-pour inspection checks of reinforcement.
- Concrete arrives on site with STRUX® 90/40 already added.

### Superior crack control

- STRUX® 90/40 fibres are evenly distributed through the concrete and always in the right place.
- Crack propagation is arrested early.

## Advantages of STRUX® 90/40 over steel fibres

The high strength to weight ratio of STRUX® 90/40 and high fineness compared to steel fibres leads to very different dosage rates of the two materials. In composite floor slabs STRUX® 90/40 is added at a dosage rate of 5.3kg/m<sup>3</sup>. A similar application using steel fibres would require a dosage of 30kg/m<sup>3</sup>.

### Clear advantages of STRUX® 90/40 include:

#### • Ease of addition:

No specialist equipment is needed to add STRUX® 90/40 to the mixing plant. A simple platform or suitable mobile steps will give safe access for adding the material.

#### • Safe & easy to handle:

Individual bags of STRUX® 90/40 are light (2.3kg), safe and easy to handle.

#### • Good pumping characteristics:

When used in conjunction with the right mix design, STRUX® 90/40 fibres display excellent pumping characteristics, minimising job downtime through equipment problems.

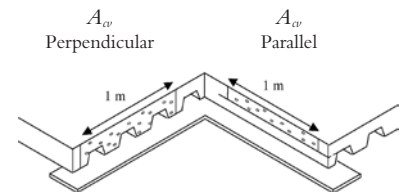
## Longitudinal shear strength

For design in accordance with BS 5950: Part 3, the shear resistance of each shear plane of concrete reinforced with 5.3 kg/m<sup>3</sup> of STRUX 90/40 fibres can be expressed as

$$v_r = 2A_{cv} \left[ + v_p \right]$$

$A_{cv}$  is the cross-sectional area of concrete per unit length of beam. Where the decking spans perpendicular to the span of the beam this area includes the concrete both above the profile and within the decking troughs. If the decking is spanning parallel to the beam then only the concrete above the profile should be considered to be resisting longitudinal shear.

To this longitudinal shear resistance may be added a component,  $v_p$ , arising from the tensile strength of the deck, but only in the situation where the deck spans perpendicular to the beam and it is either continuous across the beam or anchored to it with through-deck welded shear studs. Guidance on the calculation of  $v_p$  can be found in the appropriate section of BS 5950: Part 3.



## Shear stud resistance

Testing established that the performance of stud connectors was enhanced when embedded in specimens using concrete reinforced with 5.3kg/m<sup>3</sup> of STRUX® 90/40 fibres, compared to identical specimens using conventional reinforcement bars. This was demonstrated by an improvement in both shear resistance and ductility and demonstrates that the BS 5950-3:1990 codified stud reduction factors (k) can be adopted without additional modification.

## Guidelines for concrete producers

The following guidelines are designed to assist concrete producers with the efficient batching and dispersion of STRUX® 90/40 synthetic structural fibres and to provide concrete that has the optimum pumping, placing and finishing characteristics for composite floor slab construction.

### 1. Mix design

- 1.1 The dosage of STRUX® 90/40 for this application has been set at 5.3kg/m<sup>3</sup>. This has been determined by extensive research programmes into the behaviour of composite floors using Richard Lees Steel Decking profiles and must not be altered without engineering approval. The addition of fibres will reduce the workability and the apparent paste volume of the concrete. In order to supply a concrete with optimum pumping, placing and finishing characteristics, these effects will need to be addressed by attention to the mix design and the selection of an appropriate and proven superplasticising admixture. The recommended admixture for this application is ADVA®, supplied by Grace Construction Products.

# Decks with STRUX® 90/40

1.2 Typically we suggest that an optimum paste volume for concrete with 5.3kg/m<sup>3</sup> of STRUX® 90/40 would be achieved with a cementitious content of 360kg and a coarse to fines ratio set at 45%. Where possible, trial mixes should be performed to determine a suitable mix and Grace Construction Products will provide technical advice where requested.

1.3 The exact water content and admixture dose are best determined experimentally.

## 2. Dry batching

2.1 STRUX® 90/40 synthetic structural fibres are supplied in concrete dispersible bags; either 0.5kg or 2.3kg. The whole bags can be added into the mixing operation without the need to open them. The appropriate number of bags can be added to the empty truck prior to loading with concrete. A suitable safe loading platform or safety steps should be provided to give the operator secure access to the mixer truck.

2.2 Once the STRUX® 90/40 bags have been loaded, 200 litres of water should then be added. This water addition assists the bags to break up, releasing their contents.

2.3 On completion of the weighing of the aggregates into the weigh hopper, a small amount (e.g. 0.5 - 1.0 tonne) of preferably coarse aggregates should be released into the truck. The contents (now containing the full quantity of fibres, ~ 200 litres of water and a portion of the aggregates alone) should be mixed for 2 - 3 minutes to allow the coarse aggregates to abrade and disperse the fibres thoroughly.

2.4 The remaining aggregates and cementitious materials can now be loaded into the truck along with further water. Mixing should now proceed as usual, targeting an initial slump of 50 - 70mm, before the addition of ADVA®. Once this has been achieved, the appropriate dosage of ADVA® should be added to increase the workability to 140 - 180mm.

## 3. Wet mixing

3.1 In wet mixed plants the bags of STRUX® 90/40 are normally added directly into the mixer prior to charging with aggregates. However this procedure may depend on the mixer and overall plant specifications and it is recommended that Grace Construction Products are consulted for advice on the best method of fibre addition.

## Guidelines for contractors

These guidelines are designed to provide contractors with advice on how best to pump, place, compact and finish concrete containing STRUX® 90/40 synthetic structural fibre reinforcement for composite floor slab construction.

### 1. Concrete pumping

#### 1.1 Mix Design and Workability

When STRUX® 90/40 is used in concrete for Holorib and Ribdeck composite floor slabs it is always used at a fixed dosage of 5.3kg/m<sup>3</sup>. This requires careful attention to mix design in order to ensure that there is sufficient paste volume to coat the fibres fully. In general we recommend a pump mix with a minimum fine aggregate to coarse aggregate ratio of 45%.

STRUX® 90/40 reinforced concrete should be delivered and discharged into the pump hopper at a workability of between 140mm - 180mm, i.e. high enough to allow the concrete to fall through the hopper grill without stacking up, but not so high as to promote segregation of the concrete in the pump line, particularly while pumping has ceased during concrete truck change-over. An approved superplasticising admixture must be used to reinstate the workability lost through the addition of fibres. Grace Construction Products strongly recommends that ADVA® be used, which also provides lubrication to the concrete, reducing pumping pressures.

### 2. Concrete placing, compacting and finishing operations

#### 2.1 Placing the concrete

Placing and levelling STRUX® 90/40 reinforced concrete should be carried out exactly as per normal concrete. The high dosage of fibre reinforcement in the concrete may give the apparent appearance of over cohesiveness, but raking/levelling will not be affected and will require no more than usual effort. Additionally, where ADVA® Floor 200 has been used, this will assist the concrete in levelling, compaction and finishing.

#### 2.2 Compacting the concrete

The best plant suited for compacting fibre reinforced concrete is the 'Magi Screed' as *figure 1*;

The concrete should be compacted sufficiently to ensure that adequate paste is brought to the surface to allow easy finishing, particularly when power floating. If this method of applying some form of surface vibration to the fibre reinforced concrete is not used, then a high number of fibres will appear at the surface of the concrete. This may not be an issue if the concrete floor is being covered by insulation etc. but if the specified finish is power floating, then the use of the Magi Screed greatly assists in achieving a satisfactory surface.

#### 2.3 Finishing the concrete surface

After compaction with the Magi Screed, an easy float (*refer figure 2*) is usually passed over the concrete to close up the surface.

2.4 Once the fibre reinforced concrete has been levelled, compacted and floated, it is allowed to cure in accordance with good concreting practice. If a power float finish has been specified, then the surface of the concrete floor is usually closed up using a "panning" operation, followed by the floating operation as shown in *figure 3*.

If the type of floating machine shown in *figure 3* is used, then some fibres will be seen in the surface of the finished concrete floor.

If a ride-on machine is used (*refer figure 4*), then usually all of the fibres disappear during the floating operation.



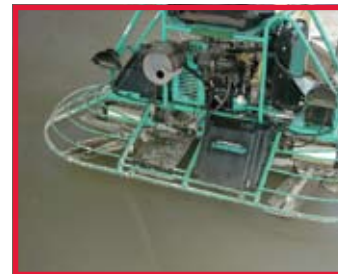
*figure 1*



*figure 2*



*figure 3*



*figure 4*

### Span/load/fire tables

1. Spans shown assume clear span +100mm to the centreline of supports.
2. Designs are fully in accordance with BS 5950: Parts 4 & 6.
3. The dead weight of the slab has been included in the development of the spans shown. However, consideration should be given to finishes, partitions, walls, etc. when reading from the table.
4. Based upon concrete densities at wet stage: normal weight concrete 2400 kg/m<sup>3</sup>, lightweight concrete 1900 kg/m<sup>3</sup>.
5. A span to depth ratio limit of 35:1 for normal weight concrete and 30:1 for lightweight concrete is generally used. Where isolated single spans occur, these should be reduced to 30:1 and 25:1 respectively.
6. Maximum deflection in the direction of span of the decking is limited to span/130 after taking account of ponding.
7. Construction stage design includes an allowance of 1.5kN/m<sup>2</sup> for construction loading.
8. Composite slabs are designed to be simply supported irrespective of the deck support configuration. The STRUX® 90/40 fibres are included to satisfy the minimum crack control and load distribution requirements of BS 5950: Part 4.
9. S350 decking is manufactured from material meeting the specification: BS EN 10326-S350GD+Z275-N-A-C. It has guaranteed minimum yield strength of 350 N/mm<sup>2</sup>.





# Ribdeck E60 with STRUX® 90/40 fibres

# 1hr Fire Rating

Span/load/fire table			Normal weight concrete									
	Support Condition	Slab Depth (mm)	Concrete Volume (m³/m²)	0.9 Gauge			1.0 Gauge			1.2 Gauge		
				Imposed Load			Imposed Load			Imposed Load		
				5.0	6.7	10.0	5.0	6.7	10.0	5.0	6.7	10.0
Multiple - Unpropped		130	0.094	3.31	3.00	2.58	3.44	3.11	2.68	3.69	3.33	2.87
		140	0.104	3.22	3.13	2.70	3.58	3.25	2.81	3.83	3.47	3.00
		150	0.114	3.14	3.14	2.82	3.49	3.37	2.93	3.81	3.60	3.12
		160	0.124	3.07	3.07	2.93	3.41	3.41	3.03	3.72	3.72	3.25
		175	0.139	2.96	2.96	2.96	3.30	3.30	3.22	3.61	3.61	3.43
		200	0.164	2.79	2.79	2.79	3.14	3.14	3.14	3.45	3.45	3.45
		250	0.214	-	-	-	-	-	-	-	-	-
Multiple - Propped		130	0.094	3.31	2.93	2.43	3.44	3.11	2.58	3.69	3.33	2.85
		140	0.104	3.45	3.07	2.54	3.58	3.25	2.71	3.83	3.47	3.00
		150	0.114	3.57	3.20	2.66	3.71	3.37	2.84	3.96	3.60	3.12
		160	0.124	3.69	3.32	2.77	3.83	3.49	2.96	4.09	3.73	3.25
		175	0.139	3.88	3.50	2.92	4.02	3.68	3.13	4.29	3.93	3.43
		200	0.164	4.18	3.76	3.15	4.32	3.98	3.40	4.60	4.23	3.71
		250	0.214	-	-	-	-	-	-	-	-	-

# Ribdeck AL with STRUX® 90/40 fibres

# 1hr Fire Rating

Span/load/fire table			Normal weight concrete									
	Support Condition	Slab Depth (mm)	Concrete Volume (m³/m²)	0.9 Gauge			1.0 Gauge			1.2 Gauge		
				Imposed Load			Imposed Load			Imposed Load		
				5.0	6.7	10.0	5.0	6.7	10.0	5.0	6.7	10.0
Multiple - Unpropped		120	0.095	3.25	2.93	2.50	3.41	3.07	2.62	3.70	3.34	2.86
		130	0.105	3.19	3.07	2.64	3.44	3.21	2.76	3.71	3.47	2.99
		140	0.115	3.12	3.12	2.75	3.36	3.32	2.88	3.62	3.60	3.11
		150	0.125	3.05	3.05	2.86	3.28	3.28	2.99	3.54	3.54	3.23
		175	0.150	2.88	2.88	2.88	3.12	3.12	3.12	3.37	3.37	3.37
		200	0.175	2.73	2.73	2.73	2.99	2.99	2.99	3.23	3.23	3.23
Multiple - Propped		120	0.095	3.25	2.93	2.50	3.41	3.07	2.62	3.70	3.34	2.86
		130	0.105	3.39	3.07	2.64	3.54	3.21	2.76	3.84	3.47	2.99
		140	0.115	3.50	3.18	2.75	3.67	3.32	2.88	3.96	3.60	3.11
		150	0.125	3.62	3.29	2.86	3.78	3.44	2.99	4.09	3.72	3.23
		175	0.150	3.95	3.61	3.16	4.12	3.77	3.29	4.43	4.06	3.54
		200	0.175	4.23	3.89	3.43	4.40	4.05	3.56	4.71	4.34	3.82

# Ribdeck 80 with STRUX® 90/40 fibres

# 1hr Fire Rating

Span/load/fire table			Normal weight concrete									
	Support Condition	Slab Depth (mm)	Concrete Volume (m³/m²)	0.9 Gauge			1.0 Gauge			1.2 Gauge		
				Imposed Load			Imposed Load			Imposed Load		
				5.0	6.7	10.0	5.0	6.7	10.0	5.0	6.7	10.0
Multiple - Unpropped		140	0.098	3.24	3.06	2.79	3.34	3.14	2.88	3.51	3.30	3.02
		150	0.108	3.46	3.26	2.96	3.56	3.35	3.05	3.73	3.52	3.21
		160	0.118	3.68	3.46	3.12	3.78	3.57	3.22	3.95	3.74	3.41
		170	0.128	3.73	3.65	3.25	4.00	3.76	3.38	4.18	3.95	3.59
		175	0.133	3.69	3.69	3.32	4.10	3.85	3.45	4.29	4.05	3.67
		200	0.158	3.50	3.50	3.50	3.92	3.92	3.75	4.60	4.52	4.03
		250	0.208	3.20	3.20	3.20	3.58	3.58	3.58	4.23	4.23	4.23
Multiple - Propped		140	0.098	3.24	3.06	2.79	3.34	3.14	2.88	3.51	3.30	3.02
		150	0.108	3.46	3.26	2.96	3.56	3.35	3.05	3.73	3.52	3.21
		160	0.118	3.68	3.46	3.12	3.78	3.57	3.22	3.95	3.74	3.41
		170	0.128	3.89	3.65	3.25	4.00	3.76	3.38	4.18	3.95	3.59
		175	0.133	3.99	3.74	3.32	4.10	3.85	3.45	4.29	4.05	3.67
		200	0.158	4.43	4.10	3.60	4.58	4.25	3.75	4.82	4.52	4.03
		250	0.208	5.07	4.71	4.18	5.25	4.87	4.32	5.59	5.18	4.60

# Ribdeck E60 with STRUX® 90/40 fibres

# 1hr Fire Rating

Span/load/fire table			Lightweight concrete									
	Support Condition	Slab Depth (mm)	Concrete Volume (m³/m²)	0.9 Gauge			1.0 Gauge			1.2 Gauge		
				Imposed Load			Imposed Load			Imposed Load		
				5.0	6.7	10.0	5.0	6.7	10.0	5.0	6.7	10.0
Multiple - Unpropped		120	0.084	-	-	-	-	-	-	-	-	-
		130	0.094	3.50	3.14	2.59	3.64	3.26	2.76	3.89	3.49	2.98
		140	0.104	3.44	3.30	2.72	3.81	3.43	2.91	4.07	3.66	3.13
		150	0.114	3.36	3.36	2.87	3.73	3.57	3.07	4.08	3.81	3.27
		175	0.139	3.19	3.19	3.19	3.55	3.55	3.40	3.88	3.88	3.62
		200	0.164	3.04	3.04	3.04	3.39	3.39	3.39	3.70	3.70	3.70
		250	0.214	-	-	-	-	-	-	-	-	-
Multiple - Propped		120	0.084	-	-	-	-	-	-	-	-	-
		130	0.094	3.43	2.99	2.46	3.64	3.21	2.62	3.89	3.49	2.89
		140	0.104	3.59	3.13	2.58	3.81	3.37	2.75	4.07	3.66	3.05
		150	0.114	3.75	3.27	2.70	3.96	3.53	2.89	4.22	3.81	3.22
		175	0.139	4.11	3.60	2.98	4.34	3.90	3.20	4.61	4.18	3.60
		200	0.164	4.42	3.89	3.23	4.69	4.23	3.48	4.97	4.53	3.94
		250	0.214	-	-	-	-	-	-	-	-	-

# Ribdeck AL with STRUX® 90/40 fibres

# 1hr Fire Rating

Span/load/fire table			Lightweight concrete									
	Support Condition	Slab Depth (mm)	Concrete Volume (m³/m²)	0.9 Gauge			1.0 Gauge			1.2 Gauge		
				Imposed Load			Imposed Load			Imposed Load		
				5.0	6.7	10.0	5.0	6.7	10.0	5.0	6.7	10.0
Multiple - Unpropped		110	0.085	3.27	2.92	2.48	3.30	3.06	2.60	3.30	3.30	2.80
		120	0.095	3.43	3.07	2.62	3.59	3.21	2.74	3.60	3.47	2.96
		130	0.105	3.41	3.22	2.75	3.69	3.37	2.88	3.90	3.64	3.10
		150	0.125	3.27	3.27	3.00	3.53	3.53	3.14	3.81	3.81	3.38
		175	0.150	3.11	3.11	3.11	3.35	3.35	3.35	3.62	3.62	3.62
		200	0.175	2.97	2.97	2.97	3.21	3.21	3.21	3.47	3.47	3.47
Multiple - Propped		110	0.085	3.27	2.92	2.48	3.30	3.06	2.60	3.30	3.30	2.80
		120	0.095	3.43	3.07	2.62	3.59	3.21	2.74	3.60	3.47	2.96
		130	0.105	3.59	3.22	2.75	3.75	3.37	2.88	3.90	3.64	3.10
		150	0.125	3.88	3.50	3.00	4.05	3.65	3.14	4.36	3.93	3.38
		175	0.150	4.29	3.89	3.36	4.46	4.05	3.50	4.78	4.34	3.75
		200	0.175	4.64	4.23	3.68	4.81	4.38	3.81	5.13	4.68	4.06

# Ribdeck 80 with STRUX® 90/40 fibres

# 1hr Fire Rating

Span/load/fire table			Lightweight concrete									
	Support Condition	Slab Depth (mm)	Concrete Volume (m³/m²)	0.9 Gauge			1.0 Gauge			1.2 Gauge		
				Imposed Load			Imposed Load			Imposed Load		
				5.0	6.7	10.0	5.0	6.7	10.0	5.0	6.7	10.0
Multiple - Unpropped		130	0.088	3.16	2.93	2.66	3.25	3.02	2.72	3.47	3.21	2.88
		140	0.098	3.39	3.17	2.86	3.49	3.25	2.94	3.68	3.43	3.10
		150	0.108	3.63	3.40	3.07	3.72	3.49	3.16	3.89	3.65	3.32
		160	0.118	3.87	3.63	3.25	3.96	3.72	3.36	4.14	3.89	3.53
		175	0.133	3.96	3.95	3.49	4.33	4.06	3.62	4.50	4.24	3.83
		200	0.158	3.77	3.77	3.77	4.22	4.22	3.98	4.95	4.79	4.25
		250	0.208	3.47	3.47	3.47	3.89	3.89	3.89	4.58	4.58	4.58
Multiple - Propped		130	0.088	3.16	2.93	2.66	3.25	3.02	2.72	3.47	3.21	2.88
		140	0.098	3.39	3.17	2.86	3.49	3.25	2.94	3.68	3.43	3.10
		150	0.108	3.63	3.40	3.07	3.72	3.49	3.16	3.89	3.65	3.32
		160	0.118	3.87	3.63	3.25	3.96	3.72	3.36	4.14	3.89	3.53
		175	0.133	4.23	3.95	3.49	4.33	4.06	3.62	4.50	4.24	3.83
		200	0.158	4.78	4.40	3.83	4.91	4.54	3.98	5.11	4.79	4.25
		250	0.208	5.60	5.14	4.50	5.78	5.31	4.65	6.11	5.63	4.93



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